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BIOLOGICAL ASSESSMENT: RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND U.S. ARMY MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

Submitted to:
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Section 1
Introduction

Section 1:

Introduction

This Biological Assessment (BA) addresses effects to Indiana bats *(Myotis sodalis)*, gray bats *(M. grisescens)* and bald eagles *(Haliaeetus leucocephalus)* caused by the proposed relocation of the U.S. Army Chemical School and U.S. Army Military Police School from Fort McClellan to Fort Leonard Wood, Missouri (Figure 1-1). Both bat species are listed as endangered, and the bald eagle is listed as threatened by the U.S. Fish and Wildlife Service (FWS).

This BA was prepared by 3D/International, Inc., Environmental Group, dba 3D/Environmental (3D/E), as a subcontractor to Harland Bartholomew and Associates, Inc. (HBA), for the U.S. Army Corps of Engineers, Kansas City District (COE). This BA was developed in accordance with 50 CFR Part 402 and the Endangered Species Act of 1973, as amended (ESA).

This BA incorporates information by reference [50 CFR Part 402.12 (g)] from the Biological Assessment of the Ongoing Mission at Fort Leonard Wood (3D/Environmental 1996a), and the Preliminary Draft Environmental Impact Statement for Relocation of the U.S. Army Chemical School and U.S. Army Military Police School to Fort Leonard Wood, Missouri (HBA 1996), hereafter referred to as the EIS. These documents are accessible to the public, and have been previously provided to the U.S. Fish and Wildlife Service, Columbia Missouri Field Office. Effects of actions proposed in this assessment are similar in nature to those analyzed in the BA

FIGURE 1-1. Location of Fort Leonard Wood, Missouri.

N

■ Fort Leonard Wood
▨ Pulasky County

3D/ENVIRONMENTAL

completed for the Ongoing Mission at Fort Leonard Wood. This assessment addresses effects to the same 3 species as the earlier BA. No habitat designated as critical occurs in the action area.

The Environmental Impact Statement assesses alternatives to implement three primary elements of the proposed BRAC action (HBA 1996). This Biological Assessment addresses only the preferred alternative (Table 1-1).

TABLE 1-1. Primary elements and alternative approaches analyzed in the Environmental Impact Statement and this Biological Assessment.

Element	Alternatives	Effects Addressed in EIS	Effects Addressed in BA
Realign Training Mission			
Army's Proposed Land Use and Facility Plan [Combined HQ and Instruction]			
	No Action Alternative	•	
	Relocate Current Practice Alternative	•	
	Optimum Preferred Training Method (Army's Proposed Action) Alternative	•	•
	Environmentally Preferred Training Method Alternative	•	
Alternative 1 Land Use and Facility Plan [Combined Headquarters]			
	No Action Alternative	•	
	Relocate Current Practice Alternative	•	
	Optimum Training Method (Army's Proposed Action) Alternative	•	
	Environmentally Preferred Training Method Alternative	•	
Alternative 2 Land Use and Facility Plan [Separate Headquarters]			
	No Action Alternative	•	
	Relocate Current Practice Alternative	•	
	Optimum Training Method (Army's Proposed Action) Alternative	•	
	Environmentally Preferred Training Method Alternative	•	
Provide Support Facilities			
	No Action Alternative	•	
	Army's Proposed Land Use and Facility Plan [Combined HQ and Instruction]	•	•
	Alternative 1 Land Use and Facility Plan [Combined HQ]	•	
	Alternative 2 Land Use Facility Plan [Separate HQ]	•	
Realign the Population			
	No Action Alternative	•	
	Phased Move Alternative	•	•

Section 2
Description of the Proposed Action

Section 2:

Description of the Proposed Action

2.1 BASE REALIGNMENT AND CLOSURE ACTIONS

This BA addresses effects of preferred alternatives of three primary elements: relocate the training mission for the Chemical and Military Police Schools, provide facilities to support the new Fort Leonard Wood mission, and realign the civilian and military population to implement the mission (Table 1-1). A detailed description of preferred alternatives is provided in Section 3 of the EIS. In general, alternatives to relocate the mission indicate *what* activities are required to train soldiers at Fort Leonard Wood. Alternatives to provide support facilities describe *where* activities/construction will occur. Alternatives of the final element address *when* realignment of the population to Fort Leonard Wood will occur.

Portions of this assessment required specific information regarding proposed actions at Fort Leonard Wood. When this information was not available, 3D/Environmental based analyses on assumed reasonable worst case scenarios. Descriptions of study methods in this document state assumptions pertinent to effect findings.

2.2 RELATED PROJECT DESIGN FEATURES

Fort Leonard Wood proposes certain management activities to assist in recovery of Indiana bats, gray bats, and bald eagles. Project design features described in this section are part of the proposed action.

2.2.1 Establish Bat Management Zones Around Freeman Cave

Gray bats are known to use Freeman Cave in all seasons except winter (see Section 5.1.1, Gray Bats on Fort Leonard Wood). Fort Leonard Wood will establish 3 bat management zones around Freeman Cave to limit potentially harmful activity near the cave. Limits on activities are identical to those currently in force for Saltpeter No. 3 Cave.

2.2.1.1 Restricted Zone

Freeman Cave is off-limits for military operations. No development will occur in the 20 acre area (162 m radius) surrounding the cave. Foot maneuvers are permitted. No smoke, CS gas, pyrotechnics, or noise simulators are permitted between 1 April and 30 October.

2.2.1.2 Bat Management Zone 1

Between 162 m and 457 m from Freeman Cave (160 ac), no bivouac, smoke, CS gas, or use of noise simulators is permitted between 1 hour before sunset to one hour after sunrise. This restriction applies between 1 April and 30 October. Foot maneuvers are permitted year-round. Development of training facilities and sites will be given a low priority within Zone 1.

2.2.1.3 Bat Management Zone 2

Between 457 m and 1932 m from the cave, disruptive activities will be given a low priority or restricted. Training activities resulting in loss of forest canopy must be approved by DPW Natural Resources Branch.

2.2.2 Establish Landscape-Scale Forest Management Policy

Fort Leonard Wood will develop and implement management to maintain or enhance the quality of forest on the Installation for endangered bats. Within 1 year of the Biological Opinion regarding this assessment, Fort Leonard Wood will produce a written policy committing to

management to maintain or enhance the quality of forest habitat on a landscape-scale. The policy statement will specify a 2-year schedule to meet the following objectives.

1. Assess current forest conditions on the Installation. Fort Leonard Wood will determine the current amount, types, and condition of forest on the Installation.

2. Describe a desired future condition for forest habitat on the Installation. The desired future condition will incorporate habitat requirements of endangered bats on a landscape-scale.

3. Utilize the best available data concerning seasonal habitat requirements of Indiana bats and gray bats to develop standards and guidelines for forest management practices on the Installation.

4. Identify unique sites such as areas near certain caves and riparian areas that require protection or special management considerations. Develop management guidelines for identified unique sites.

Fort Leonard Wood will coordinate with the U.S. Fish and Wildlife Service (FWS) in developing and meeting these objectives. Future forest management actions will follow the standards and guidelines. Fort Leonard Wood will submit annual reports to the U.S. Fish and Wildlife Service documenting forest management actions and compliance with established standards and guidelines.

2.2.3 Implement Erosion Control Measures During Construction

Fort Leonard Wood will implement erosion control measures during proposed construction. These measures will minimize the movement of sediment towards streams utilized by bald eagles. Standard erosion control measures in place for all BRAC-related construction are described below.

- Vegetative and structural erosion control practices will be constructed and maintained according to standards and specifications of the State of Missouri Department of Natural Resources and/or the EPA document entitled Storm Water Management for Construction Activities.

- Construction shall follow Missouri Clean Water Law requirements for construction activities.

- All erosion and sediment control measures are to be in place prior to or as the first step in construction.

- All areas disturbed by construction activities shall be seeded and mulched or sodded and fertilized unless otherwise the area is to be paved or built upon.

2.2.4 Design and Implement Monitoring Program

A biomonitoring program will be prepared to assess effects of the BRAC action. The plan will develop a monitoring strategy to assess changes in habitat of Indiana bats, gray bats, and bald eagles; alterations of prey populations or prey habitat, or alteration of other elements of the ecosystem that directly influence survivorship of these species. Biocriteria, chemical specific parameters, toxicity tests, and prey enumeration techniques will be selected and incorporated in the biomonitoring plan. Biomonitoring will allow detection of changes and monitoring of physical, chemical, and biological components of terrestrial and aquatic habitats at Fort Leonard Wood.

Section 3
Studies Completed for the Biological Assessment

Section 3:

Studies Completed for the Biological Assessment

The BA analyzes potential for, and magnitude of, direct, indirect, and cumulative effects based upon the best available scientific and commercial data, including studies described in this document. Fort Leonard Wood has completed extensive studies where effects of the proposed action could not be adequately assessed using information currently available.

Potential effects of proposed BRAC actions on listed species can be grouped in 3 general categories:

- *Habitat modification resulting from proposed range, facility, and other construction.*

  3D/Environmental applied a habitat suitability index model to quantify effects of proposed construction projects to Indiana bat summer habitat. Effects to gray bat summer habitat and bald eagle winter habitat were qualitatively assessed with the use of Geographic Information Systems and aerial photography.

- *Disturbance caused by air- and substrate-bome sound generated by military training.*

  3D/Environmental completed laboratory studies to assess effects of air- and substrate-bome sound on hibemating Indiana bats. We monitored the response of a surrogate species *(Myotis lucifugus)* to stimuli approximating sounds generated by BRAC training.

We assessed characteristics of sounds reaching caves used by gray bats. We evaluated potential effects of these sounds using the best available information. A similar approach was used to assess the effects of military-generated sound on bald eagles.

- *Effects caused by exposure to toxicological agents.*

  3D/Environmental assessed the potential for toxicological effects to Indiana bats, gray bats, and bald eagles. We evaluated effects of training materials to be used in the proposed action, including fog oil and terephthalic acid obscurants, Biological Integration Detection System (BIDS) training simulants, FOX training simulants, and non specific simulants. An Ecological Risk Assessment was completed (Appendix IV).

Section 4
Indiana Bat (*Myotis sodalis*)

Section 4:

Indiana Bat
(Myotis sodalis)

4.1 BACKGROUND

3D/Environmental provides a detailed description of the species in the Biological Assessment of the Master Plan and Ongoing Mission (1996). Section 4 of that document describes the species' life history and existing Installation management guidelines. We incorporate those sections by reference.

4.1.1 Indiana Bats on Fort Leonard Wood

Indiana bats occur on Fort Leonard Wood year-round. Hibernating populations are known from Wolf Den, Brooks, Davis No. 2 and Joy caves on the Installation (Figure 4-1). Indiana bats also hibernate in Great Spirit Cave, 5.6 km west of the Installation. Caves on and near Fort Leonard Wood (Table 4-1) support approximately 1000 individuals, or approximately 0.3% of the total species population in 1995.

The Indiana bat population across the species range (as recorded from counts in hibernacula) has declined since the late 1970's. Declines have been most dramatic in Missouri, where the highest statewide population (353,000) was recorded in 1979. The 1991 Missouri population was approximately 54% of the recorded high (MDC, March 1, 1995 letter to Russ Rommé, 3D/E; MDC, November 24, 1993 Natural Heritage Database).

TABLE 4-1. Indiana bat populations in hibernacula on and near Fort Leonard Wood, Missouri. Years or caves without survey data are indicated (-).

Year	Wolf Den	Brooks (Priority 2)*	Davis No. 2	Joy	Great Spirit (Priority 2)*
1954	-	-	-	-	2000
1978	-	19,500	-	-	-
1979	19	19,500	-	-	-
1980	-	-	-	-	4000
1981	-	12,000	-	-	1800
1983	-	11,150	-	-	1600
1985	-	5500	-	-	500
1987	-	-	-	-	40
1989	-	3050	-	-	35
1991	29	2700	-	-	450
1992	-	1550	-	-	625
1994	-	-	95	131	-
1995	-	750	-	-	450
1996	3	536	34	19	-

* Priority 1 hibernacula are caves with recorded maximum populations greater than 30,000 since 1960. Priority 2 hibernacula have maximum recorded populations since 1960 between 1000 and 30,000.

Indiana bat populations on Fort Leonard Wood have declined (Table 4-1). Populations in Brooks Cave have declined over 95% since the 1970's. The population in Great Spirit Cave appears stable over the last several years, however the population in 1992 was only 15% of the highest recorded population in the cave. Data are insufficient to describe population trends in Wolf Den, Davis No. 2, and Joy caves.

Of Indiana bat hibernacula on, or near the Installation, only Great Spirit Cave has a barrier restricting human entry. A chain link fence, topped with barbed-wire, surrounds the cave. A barbed-wire livestock fence surrounds Wolf Den Cave, but does not discourage human entry into the cave. Access to caves within the Installation boundary is controlled by regulation. Signs are posted at entrances to Brooks, Wolf Den, Joy, and Davis No. 2 caves indicating dates when entry is prohibited.

Indiana bats are present on the Installation during spring staging and fall swarming. Telemetry studies were conducted for the Ongoing Mission BA, and are summarized in Sections 4.4 - 4.6 of that document. Indiana bats used areas between 173 acres and 13,090 acres

during the spring. Females (n = 2) used areas averaging 844 acres (s.d. = 948 acres), foraging ranges of males (n = 4) averaged 6837 acres (s.d. = 5300 acres). Indiana bats tracked during autumn used areas ranging from 809 acres to 15,774 acres.

Indiana bats also occur on the Installation during the summer. Females typically arrive at summer maternity areas in April and May. They form nursery colonies under exfoliating bark of dead trees, or living trees such as shagbark hickory *(Carya ovata)* in upland or riparian forest. A single maternity colony may consist of over 100 individuals (Gardner et al. 1991a). Maternity colonies are found in a variety of other tree species, including slippery elm (*Ulmus rubra*), American elm (*U. americana*), cottonwood (*Populus deltoides*), northern red oak (*Quercus rubra*), post oak (*Q. stellata*), white oak (*Q. alba*), shingle oak (*Q. imbricaria*), sassafras (*Sassafras albidum*), sugar maple (*Acer saccharum*), silver maple (*A. saccharinum*), green ash (*Fraxinus pennsylvanica*), and bitternut hickory (*C. cordiformis*).

Females typically give birth between late May and early July. Juveniles begin to fly between early July and early August. By late September, most females have left summer areas and returned to hibernacula.

Indiana bats forage during the summer in upland and floodplain forest (Brack 1983, Humphrey et al. 1977, LaVal et al. 1977, LaVal and LaVal 1980, Gardner et al. 1991a). Foraging activities of Indiana bats are generally concentrated from 6 to 90 feet (2 to 30 m) above the ground near the foliage of trees (Humphrey et al. 1977, Brack 1983). Indiana bats use stream corridors and forest openings as flight corridors from roosts to foraging areas.

Two reproductively active female Indiana bats, and a nonreproductive adult male Indiana bat were captured within Installation boundaries in 1994 (see Section 4.5.4 of the Ongoing Mission BA) (Figure 4-1). Capture of the adult male within 3 km of Wolf Den Cave and 4 km of Brooks Cave was predictable. Males have been documented at other hibernacula throughout the summer (Hall 1962, LaVal and LaVal 1980). Capture of two reproductively active female Indiana bats indicates the presence of one or more maternity colonies on, or within several kilometers of the Installation.

4.1.2 Scope of Analysis

This biological assessment focuses upon portions of the BRAC action with reasonable potential to affect Indiana bats. We assessed 3 general categories of effects in Sections 4.1.2.1 through 4.1.2.3 below.

4.1.2.1 Effect of Habitat Modification Caused by Proposed Construction

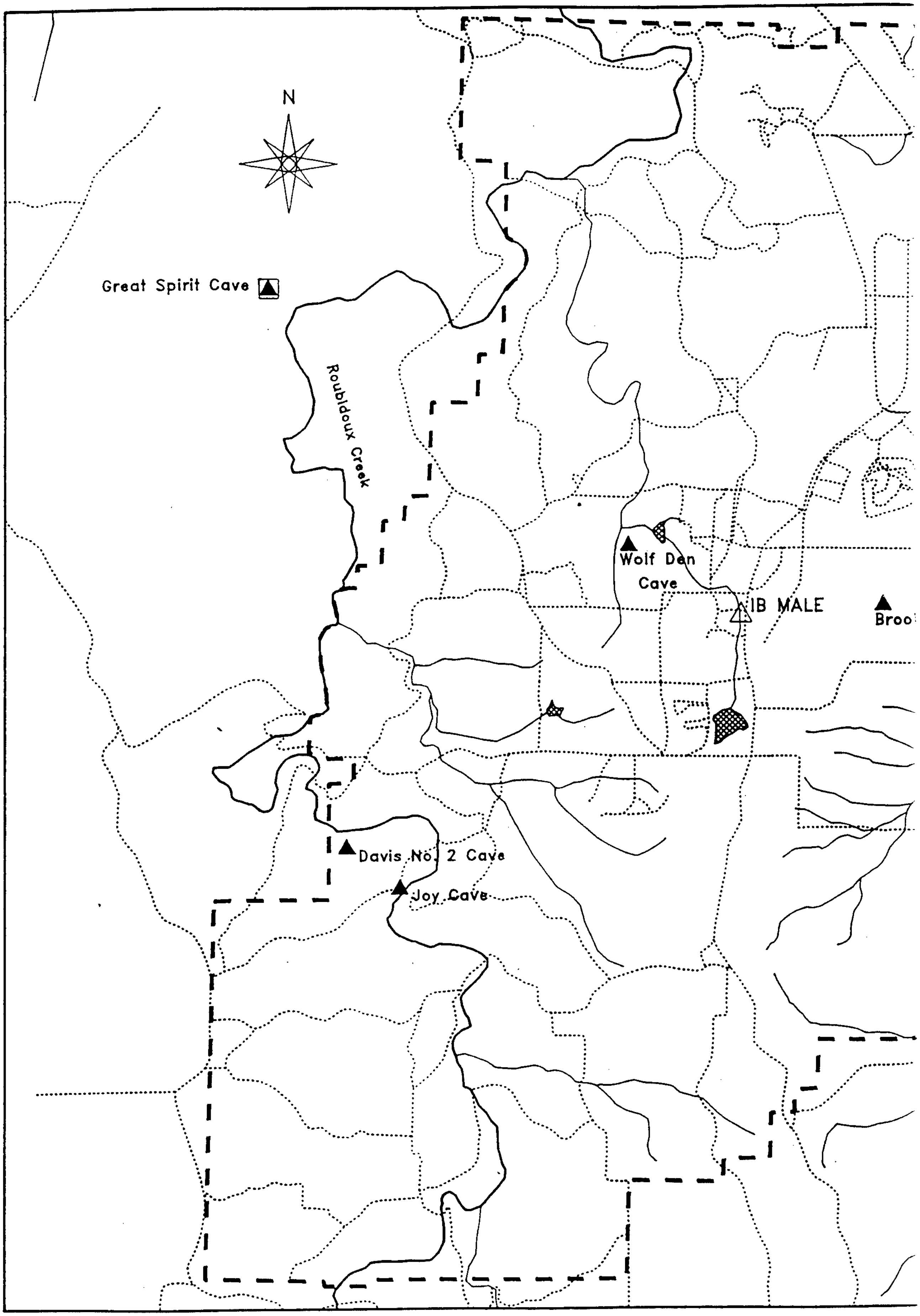
The proposed action includes construction and modification of buildings, training ranges and other support facilities (Figure 4-2). We assessed effects to summer habitat suitable for male, female, and/or juvenile Indiana bats. The quality and quantity of habitat at proposed construction sites were characterized and evaluated using a habitat suitability index model (Rommé et al. 1995).

4.1.2.2 Effect of BRAC-Related Sound on Hibernating Indiana Bats

The proposed BRAC action will bring training to Fort Leonard Wood which will utilize equipment new to the installation. In addition, new training missions will require relocation of several existing training ranges. We assessed effects of sound generated by new equipment (M56 mobile smoke generator and M157 mobile smoke generator), by construction of BRAC support facilities, and relocated training activities on Range 3, Range 4, Range 6, Range 10, Babb Airfield (Air Force Base Recovery), and 16 Building MOUT (Military Operations in Urbanized Terrain) to hibernating Indiana bats in Brooks, Wolf Den, Joy, and Davis No. 2 caves on Fort Leonard Wood.

Proposed training ranges near Indiana bat hibernacula are described in Table 4-2 and Figure 4-2. Sound sources from these training ranges which were examined for impacts to hibernating Indiana bats are summarized in Table 4-3.

We examined only conservative scenarios for potential impacts of sound or vibration to hibernating Indiana bats. We assumed worst-case sound conditions emanating from BRAC training ranges (e.g., all smoke generators operating simultaneously). Given a particular sound source, distance is the most important factor influencing sound levels reaching hibernacula. Therefore, we examined sound generated only by proposed BRAC construction or training activities closest to hibernacula (Figure 4-3).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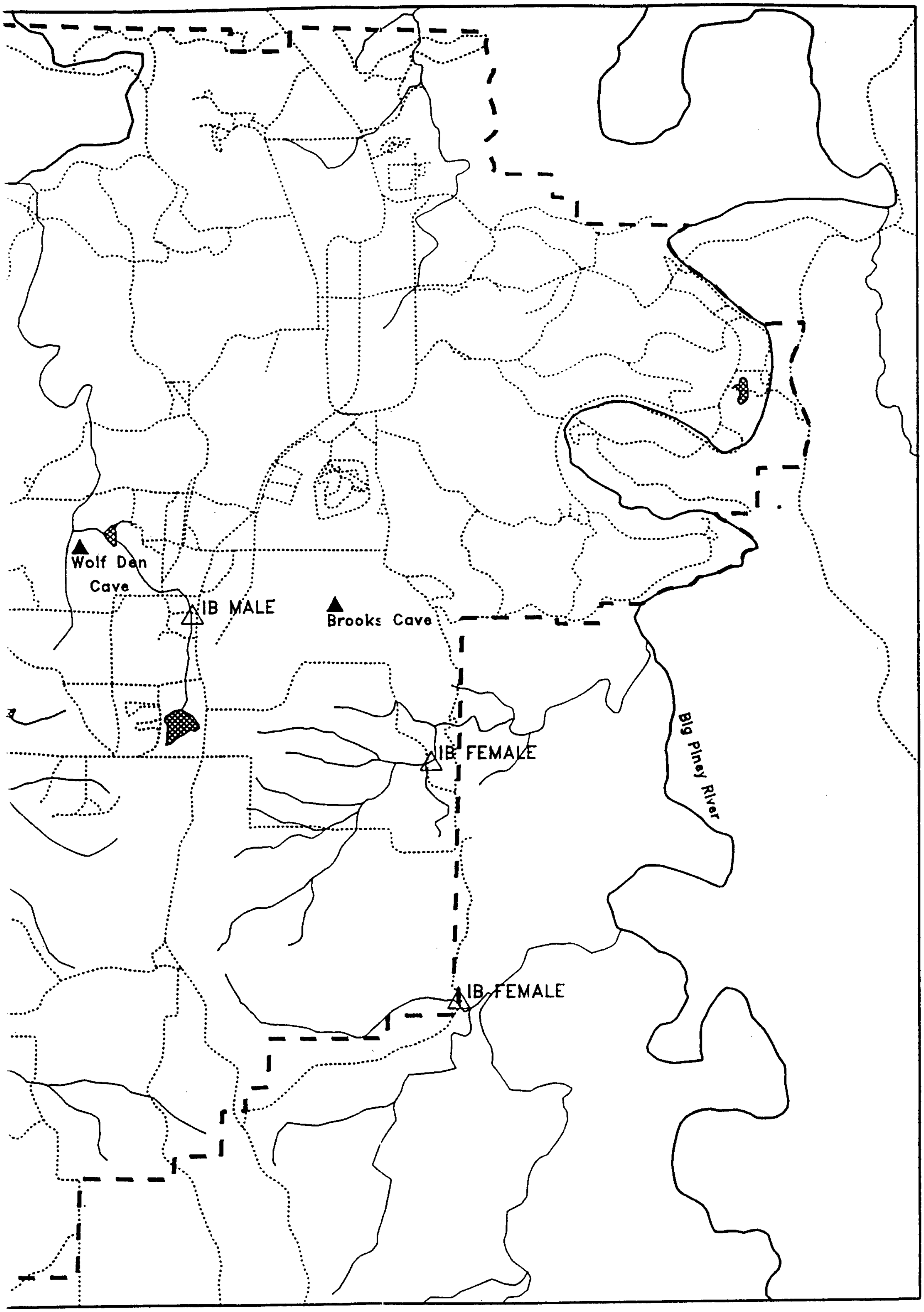
Great Spirit Cave
Roubidoux Creek
Wolf Den Cave
IB MALE
Broo
Davis No. 2 Cave
Joy Cave



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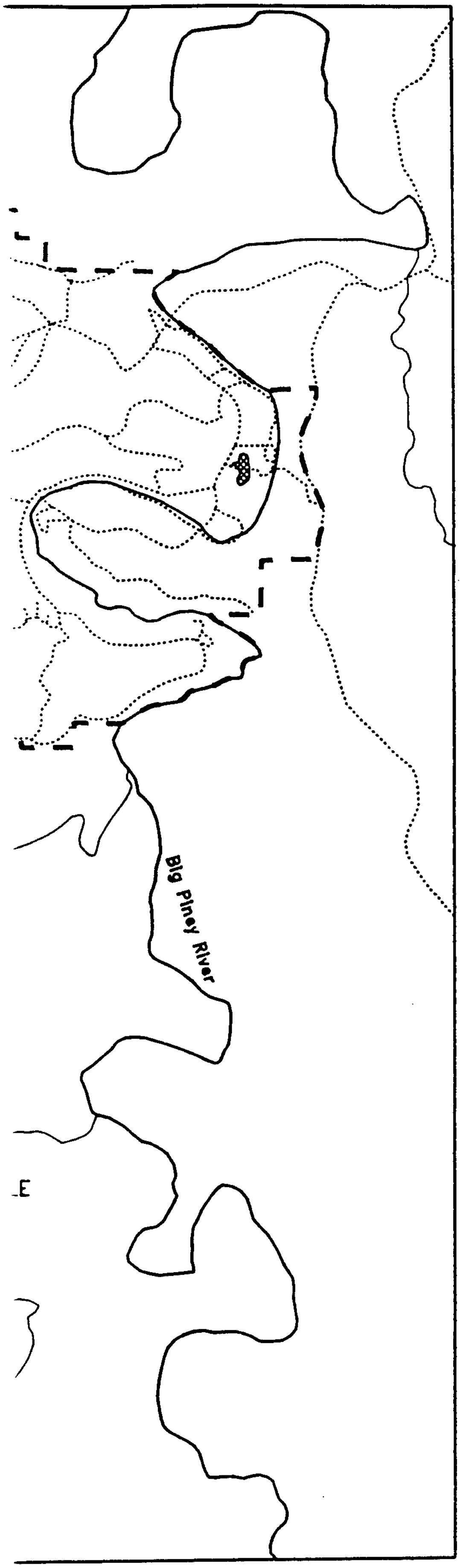

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RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 4–1. Indiana bat hibernacula and Indiana bat capture sites on or near Fort Leonard Wood, Missouri.

▲ Indiana Bat Hibernaculum

Indiana Bat Hibernaculum/ Gray Bat Cave

△ Indiana Bat Mist Net Capture Site

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers
0 2 4

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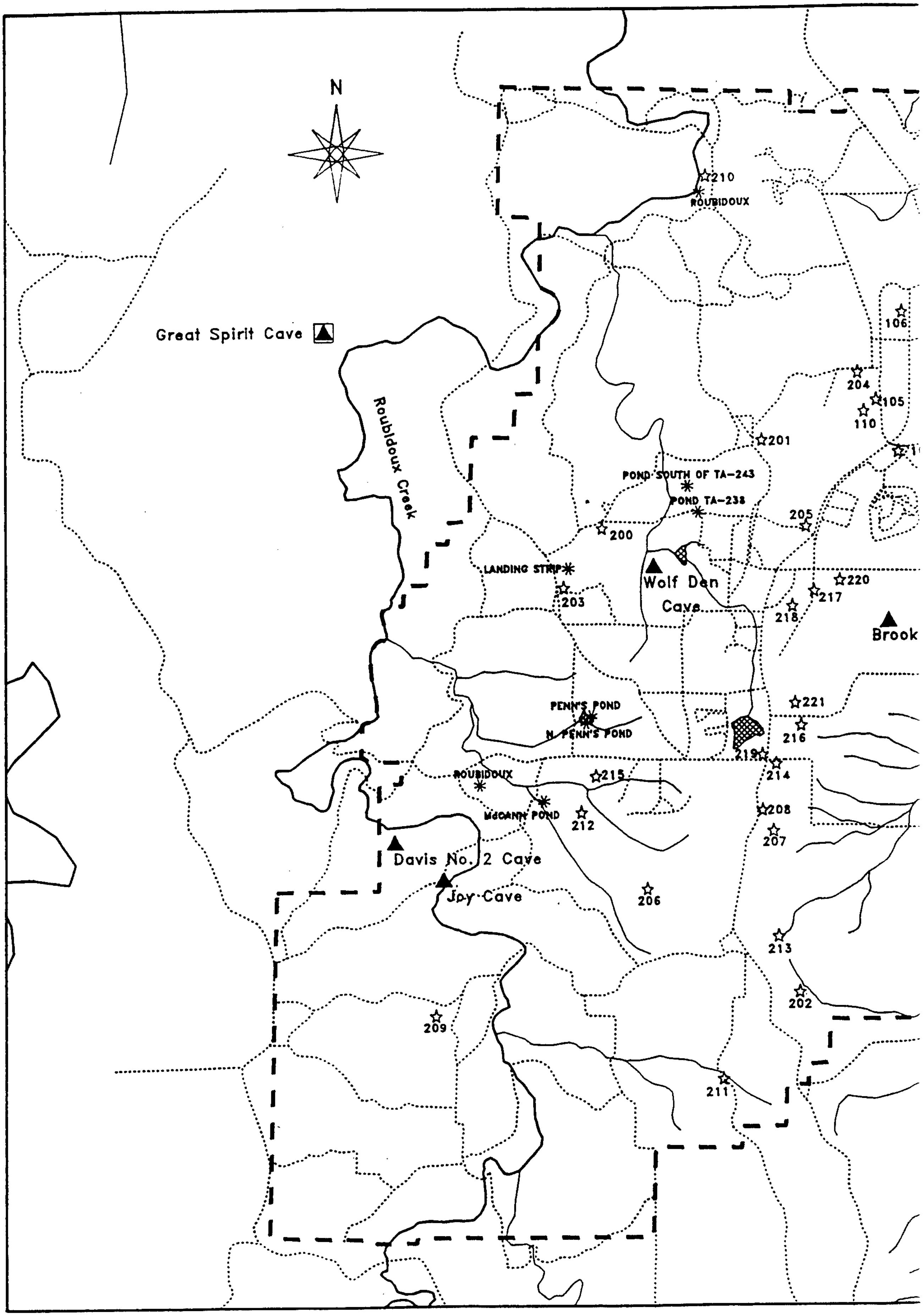
TABLE 4-2. Proposed training ranges near Indiana bat hibernacula on Fort Leonard Wood which produce significant levels of sound. Sounds associated with these activities were examined for effects to hibernating bats.

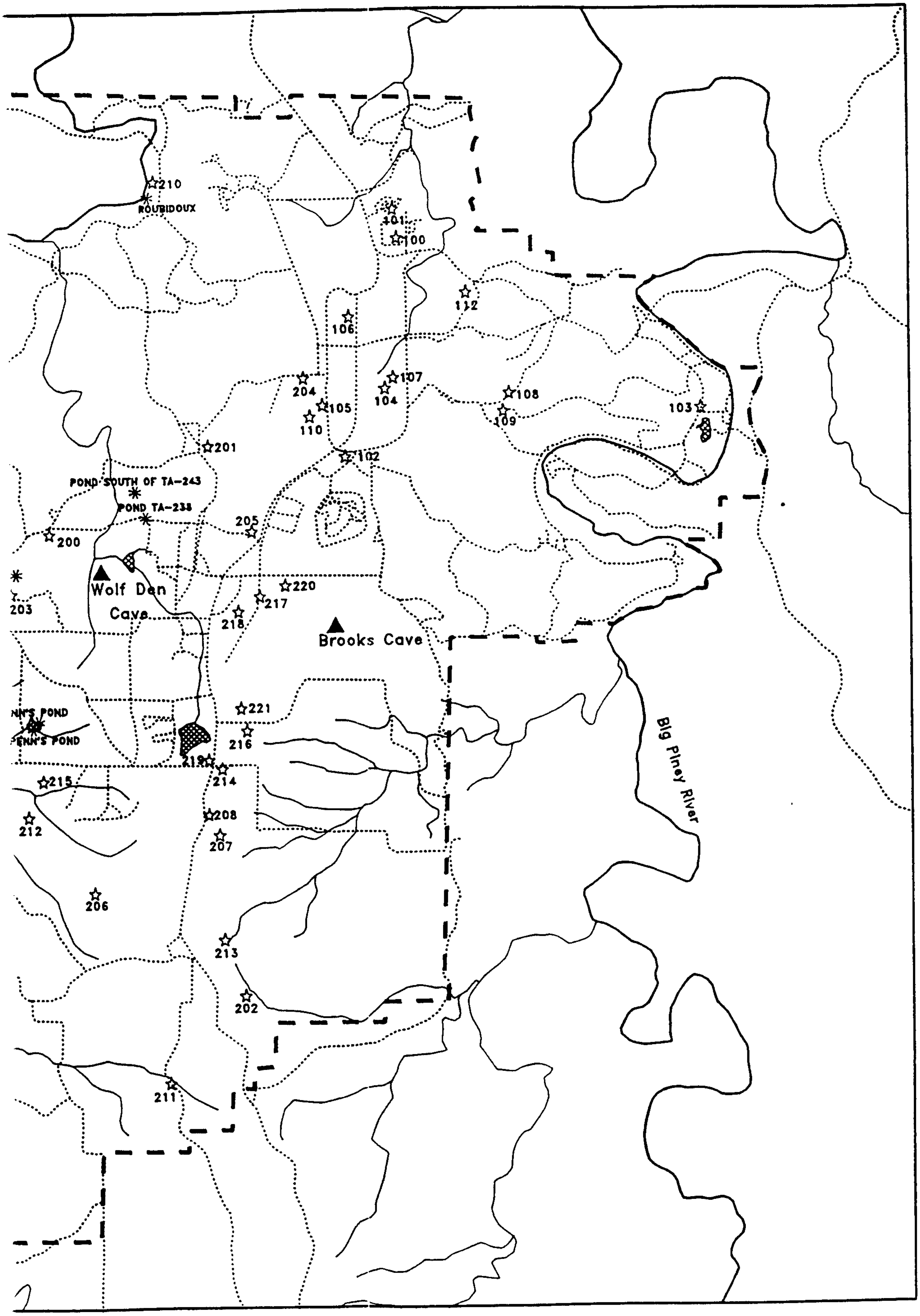
Cave	Proximate Training Ranges	Description of Training	Distance Between Cave and Range (m)
Brooks	Range 3	Zero Fire M16	1300
	Range 4	Night Infiltration Course	1615
	Range 6	Fire and Maneuver Course	2250
	Range 10	U.S. Weapons	2700
Davis No. 2	Mobile Smoke TA (Bailey/McCann)	Obscurant, Employment Proficiency Test	2420
Joy	Mobile Smoke TA (Cannon Range)	Obscurant, Employment Proficiency Test	1750
Wolf Den	16 Building MOUT	Military Operations in Urbanized Terrain	1188
	Babb Airfield	Air Force Base Recovery	1720

TABLE 4-3. BRAC-related sound sources evaluated for impacts to hibernating Indiana bats and associated training ranges proposed near Indiana bat hibernacula on Fort Leonard Wood.

Training Range(s)	Sound Source
Range 3	Small Arms - 5.56 mm (M16)
Range 4	Night Infiltration Training - 5.56 mm (M16), 7.62 mm (M60), Ball and Tracer, Demolition and Artillery Simulators
New Construction Projects	Construction Equipment - bulldozers, earthmovers, clamshells, graders, and scrapers
Range 6	Small Arms - 5.56 mm (M16)
Range 10	Claymore Mines, 7.62 mm (M60), 40 mm Grenades (M781 and M406) launched from M203 and AT4
Mobile Smoke Training Areas	M56 Smoke Generator
Mobile Smoke Training Areas	M157 Smoke Generator
16 Building MOUT	Military Operations in Urbanized Terrain (MOUT) - 5.56 mm (M16) and 7.62 mm (M60)
Babb Airfield	Air Force Base Recovery - sirens, vehicles, generators and blowers, decontamination apparatus



N
Great Spirit Cave
Roubidoux Creek
210
ROUBIDOUX
106
204
105
110
201
POND SOUTH OF TA-243
POND TA-238
205
200
LANDING STRIP
203
Wolf Den Cave
220
217
218
Brook
PENN'S POND
N. PENN'S POND
221
216
219
214
ROUBIDOUX
215
McCANN POND
212
208
207
Davis No. 2 Cave
Joy Cave
206
213
202
209
211



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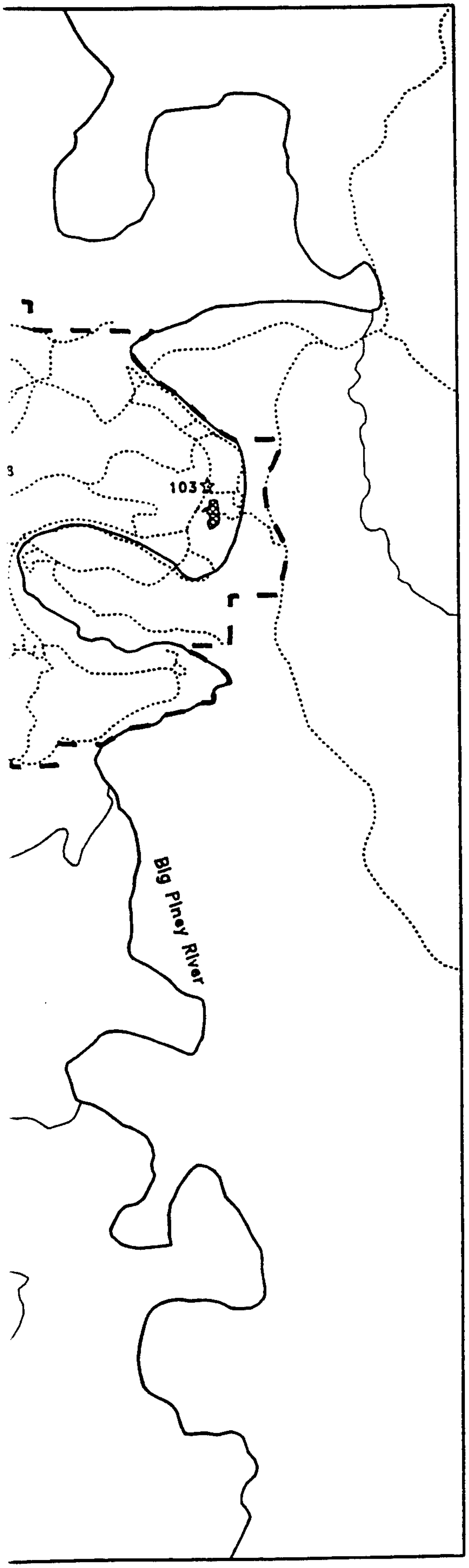

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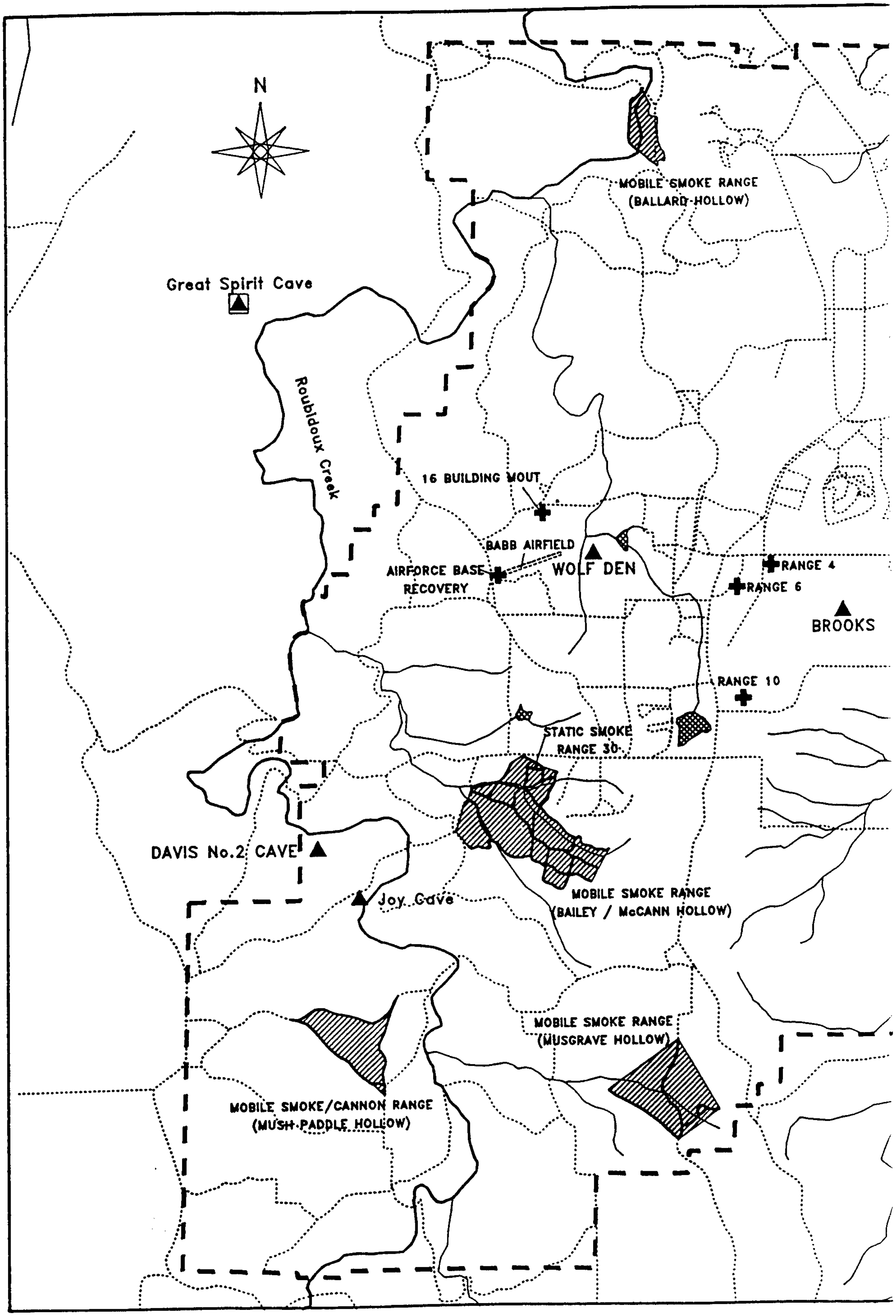
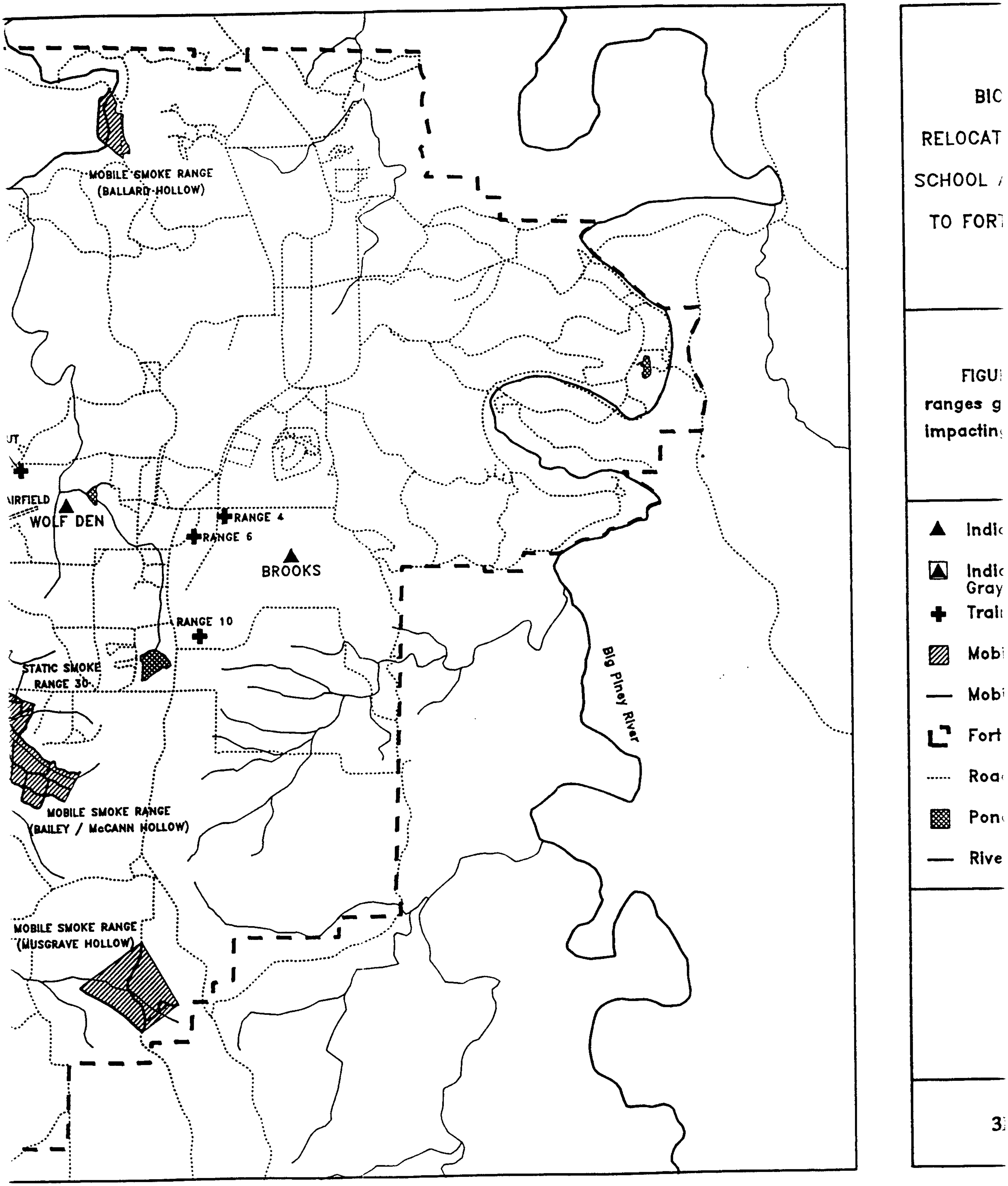
FIGURE 4–2. Proposed locations of new facilities and BRAC training, and Indiana bat hibernacula on Fort Leonard Wood, Missouri. Numbers refer to project descriptions in Table 4–7.

- Indiana Bat Hibernaculum
- Indiana Bat Hibernaculum/ Gray Bat Cave
- New Support Facility
- Potential Decontamination Site
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream

Kilometers
0 2 4

3D/ENVIRONMENTAL


N
MOBILE SMOKE RANGE
(BALLARD HOLLOW)
Great Spirit Cave
Roubidoux Creek
16 BUILDING MOUT
BABB AIRFIELD
AIRFORCE BASE
RECOVERY
WOLF DEN
RANGE 4
RANGE 6
BROOKS
RANGE 10
STATIC SMOKE
RANGE 30
DAVIS No.2 CAVE
Joy Cave
MOBILE SMOKE RANGE
(BAILEY / McCANN HOLLOW)
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)
MOBILE SMOKE/CANNON RANGE
(MUSH PADDLE HOLLOW)



MOBILE SMOKE RANGE
(BALLARD HOLLOW)
UT
IRFIELD
WOLF DEN
RANGE 4
RANGE 6
BROOKS
RANGE 10
STATIC SMOKE
RANGE 30
MOBILE SMOKE RANGE
(BAILEY / McCANN HOLLOW)
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)
Big Piney River
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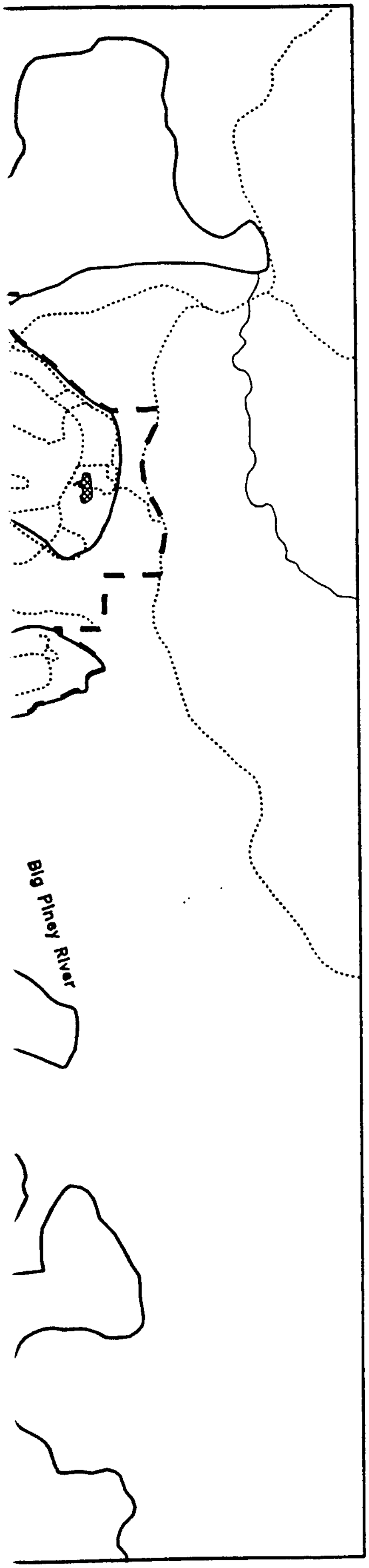

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FIGURE 4–3. BRAC–related training ranges generating sound potentially impacting Indiana bats in hibernacula.

- ▲ Indiana Bat Hibernaculum
- Indiana Bat Hibernaculum/ Gray Bat Cave
- ✚ Training Range
- Mobile Smoke Training Area
- — Mobile Smoke Deployment Road
- Fort Leonard Wood Boundary
- ...... Road
- Pond
- — River / Stream

Kilometers
0 2 4

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4.1.2.3 Effect of Exposure to Toxicological Agents

Indiana bats may be exposed to training substances when they roost in trees or forage during spring staging, during the summer maternity season, and during fall swarming. Indiana bats hibernating in Brooks, Davis No. 2, Wolf Den, and Joy caves on the Installation, and in Great Spirit Cave near Fort Leonard Wood may also be exposed. 3D/Environmental assessed the potential for toxicological effects from exposure to a variety of training materials (Appendix IV, Attachment A).

- Certain materials were excluded from detailed analysis in a preliminary screening. Exclusion was based upon an assessment of toxicity, quantity to be used, storage and use location, and method of deployment (Appendix IV, Attachment A).
- Certain other training materials were assumed to be of limited threat to listed species, and were not evaluated in detail. Potential effects of these substances will be assessed in a biomonitoring plan to be implemented by the Installation (see Section 2.2.4).
- Certain materials were excluded from detailed analysis based upon results of a screening level risk assessment (Appendix IV, Attachment A).
- Remaining training materials were evaluated in detail in an Ecological Risk Assessment (Appendix IV). We evaluated effects of fog oil (obscurant), terephthalic acid (grenades and smoke pots), and titanium dioxide (grenades).

We assumed exposure to toxic concentrations of any stressor would result in an effect. Maximum concentrations at which stressors were nontoxic were converted to toxicity values or doses (e.g. NOAEL = No Observable Adverse Effects Level) not expected to result in adverse health effects. Because toxicity data were derived from studies of laboratory animals (e.g. rats), uncertainty factors (UF) were applied when deriving toxicity values for receptors. Uncertainty factors account for anatomical, physiological, taxonomic, or morphological differences between species for which the dose was calculated and the species of concern.

Toxicity Reference Values (TRV) were developed by applying uncertainty factors to the doses (TRV = NOAEL/Uncertainty Factors) following Department of Army guidelines (Wentsel et al. 1994) and procedures outlined in Calabrese and Baldwin (1993). TRVs provide conservative estimates for toxicological effects levels where species-specific toxicity data are lacking. For example, most Indiana bat TRVs in this BA were derived by reducing toxicity values of other mammals by a factor of 1600 (1600 is the product of several multiplicative uncertainty factors). The TRV approach is similar to the RfD approach used in human health risk assessments. Most

RfDs developed for humans are derived from non-human toxicity values reduced by uncertainty factors ranging from 10 to 10,000.

For fog oil, BIDS simulants, FOX Training simulants, and non-specific simulants, we determined acute and chronic toxicity values available in the literature. We calculated acute and chronic toxicity of TPA using BATS.XLS (3D/Environmental 1996).

Toxicological effects exhibited by test species from which TRVs were derived may or may not adequately characterize effects likely to be manifested in receptors we evaluate here. Common test species, such as rats, mice, and guinea pigs may demonstrate different effects than can be expected in bats or eagles. "Critical Effects" listed in Appendix IV, Section IX are manifested by test species, not Indiana bats. Where we predict receptors will be exposed to unsafe concentrations, we do not necessarily expect Critical Effects will result. We list Critical Effects as a reference only. Inferences from Critical Effects must be made with caution. Our description of specific effects likely to be manifested by Indiana bats is limited by available toxicity data.

Development of acute and chronic toxicity values for the receptors in this analysis is beyond the scope of this Biological Assessment. These tests, if completed for the numerous potential contaminants evaluated, are expensive, time consuming. It is common practice to extrapolate toxicity values from test species to the species of interest.

Fog Oil

Fog oil has had several designations in its history which may lead to confusion. There are two types of fog oil, "old" fog oil and "new" fog oil. Fog oil also has letter designations used by the military for purchasing or issuing requests for production from manufacturers. Types A and B are "old" fog oil (also referred to as SGF 1) that were manufactured under specifications A and B before 1986. "New" fog oil, designated as type D, is also referred to as SGF 2 fog oil (Standard Grade Fuel 2). It is the primary material used by the military to produce smoke at Fort McClellan and other Department of Defense installations.

Fog oil designated as D is currently used at Fort McClellan, Alabama. Fog oil type D or E will be used at Fort Leonard Wood. The chemical composition of Type D and E is the same.

The different designations indicate tests required of manufacturers. Mutagenicity tests are required for fog oil type D, mutagenicity and carcinogenicity tests are required on type E.

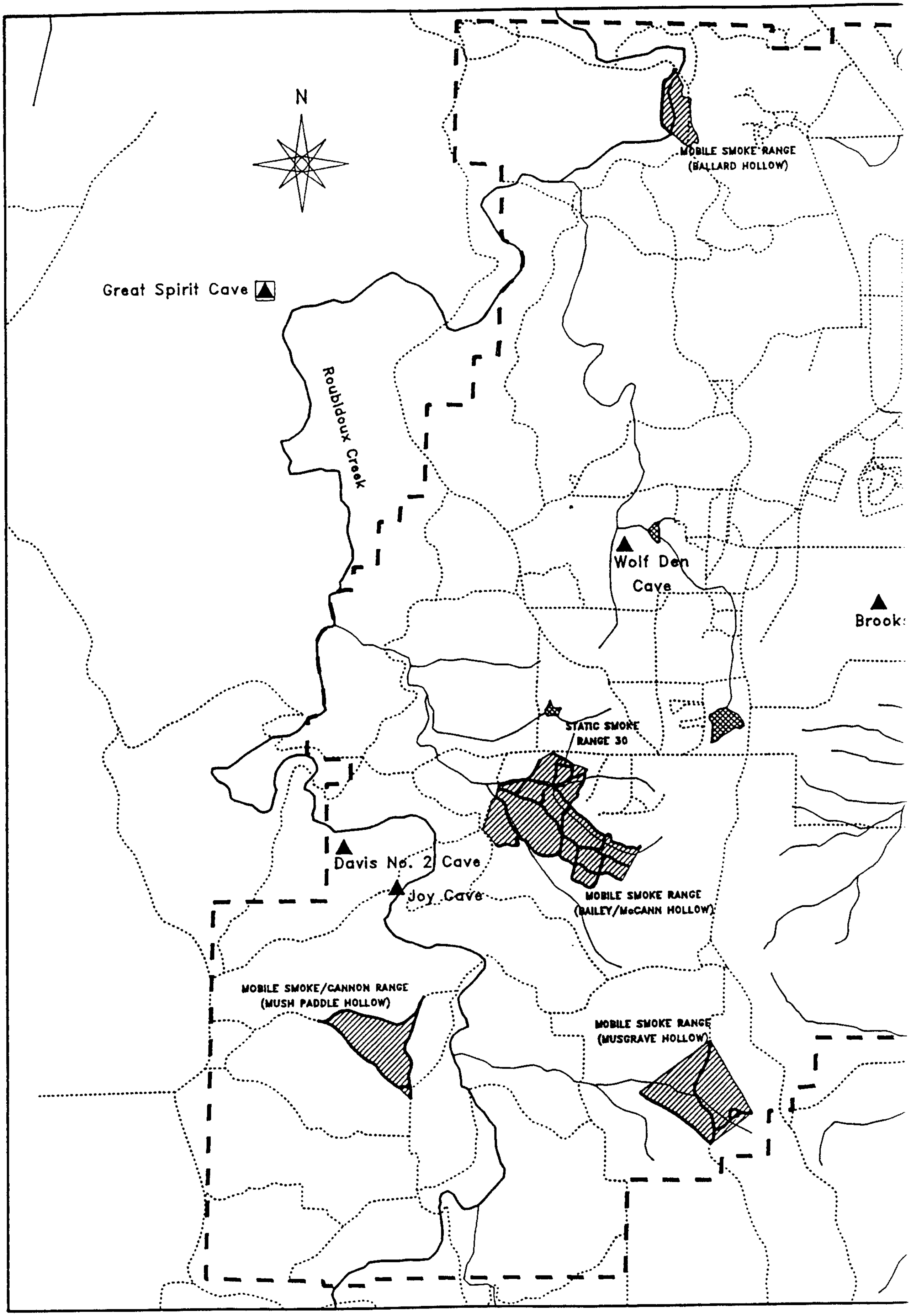
Mobile fog oil training (Training Activities 7.3 and 7.4 in the Environmental Impact Statement assessing effects Relocation of U.S. Army Chemical School and U.S. Army Military Police School to Fort Leonard Wood, Missouri) is proposed in 4 areas: Musgrave Hollow, Ballard Hollow, Cannon Range (Mush Paddle Hollow), Bailey/McCann Hollow. Static training (Training Activity 7.2) is proposed only at Range 30F (Figure 4-4). The number of fog oil generators and fog oil consumption varies by training activity (Table 4-4), and training area (Appendix IV, Section 5.3 and Attachment I, Table I-5).

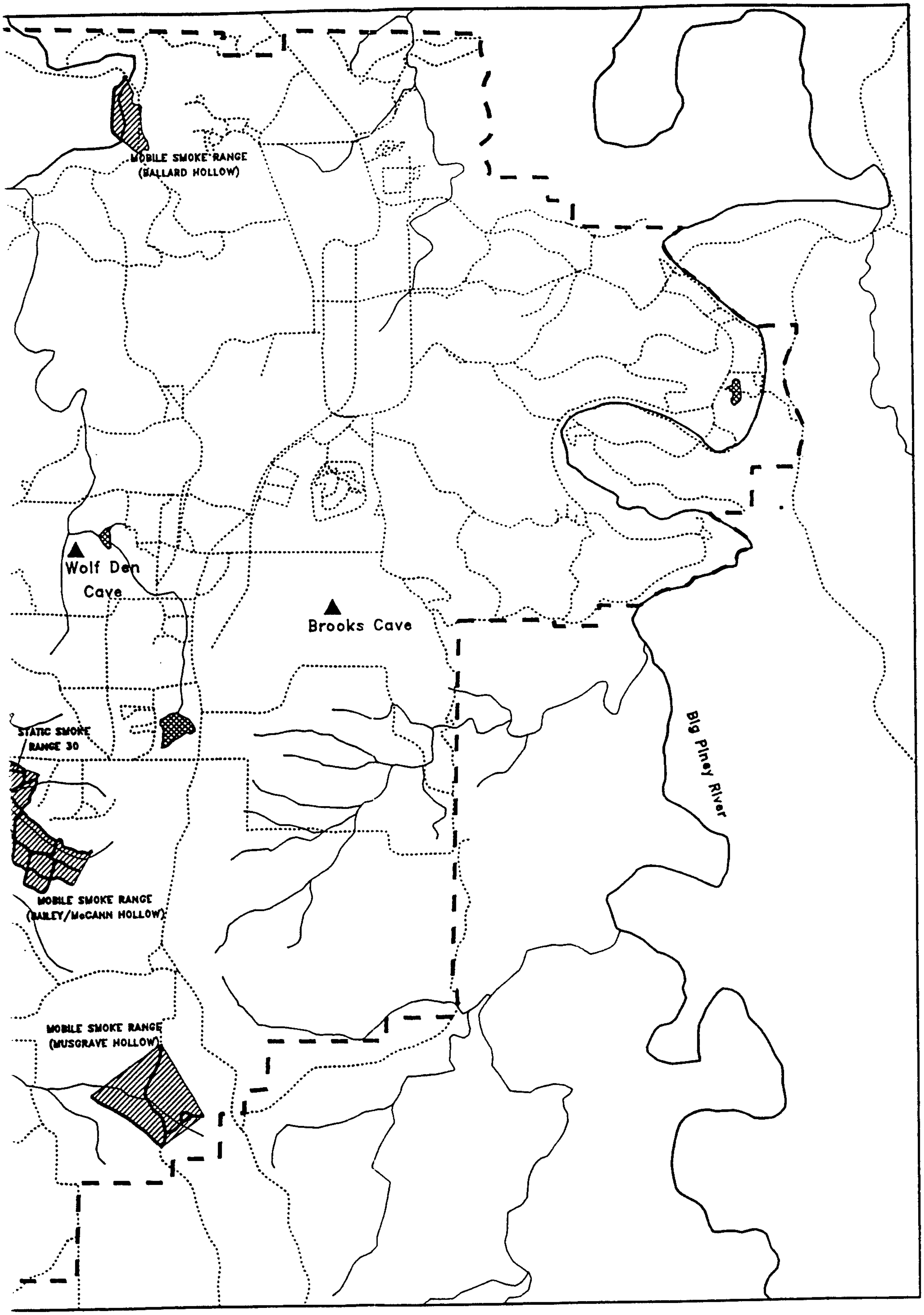
We assessed effects assuming contaminants reach watercourses. We believe fog oil will not cause indirect effects to listed species. 3D/Environmental (1996c) evaluated the environmental fate of fog oil at Fort McClellan, Alabama. No increase of fog oil hydrocarbons were noted in soil, surface water, sediment, tree bark, leaf, insect, or bat tissue samples taken from fog oil exposure sites. Fog oil is biodegradable and will remain in soil only a few days, depending on soil fauna present and time of year fog oil is released.

Harmful quantities of fog oil are not expected to accumulate in the environment at Fort Leonard Wood because fog oil is readily biodegraded by aerobic microorganisms. Large quantities of fog oil will not reach caves, groundwater, or other water systems via soil erosion, deposition, or storm water runoff. When fog oil enters water, it is rapidly attenuated due to its water solubility. Fog oil is biodegraded by microorganisms, and undergoes chemical degradation in aqueous environments. We do not anticipate accumulation of fog oil or its components in soil, groundwater, or surface water at Fort Leonard Wood. Prey are unlikely to be affected by exposure to fog oil through aquatic pathways.

Terephthalic Acid

Terephthalic acid (TPA) will replace hexachloroethane (HC) by fiscal year 1999. HC is being replaced by TPA because TPA is noncarcinogenic and it's combustion products are less toxic than those of HC. TPA is used in floating or ground smoke pots, and in smoke grenades. TPA is ignited and burned to produce smoke. It is used alone, or in combination with fog oil to fill in incomplete fog oil screens.


N
MOBILE SMOKE RANGE
(BALLARD HOLLOW)
Great Spirit Cave
Roubidoux Creek
Wolf Den
Cave
Brook
STATIC SMOKE
RANGE 30
Davis No. 2 Cave
Joy Cave
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
MOBILE SMOKE/CANNON RANGE
(MUSH PADDLE HOLLOW)
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)



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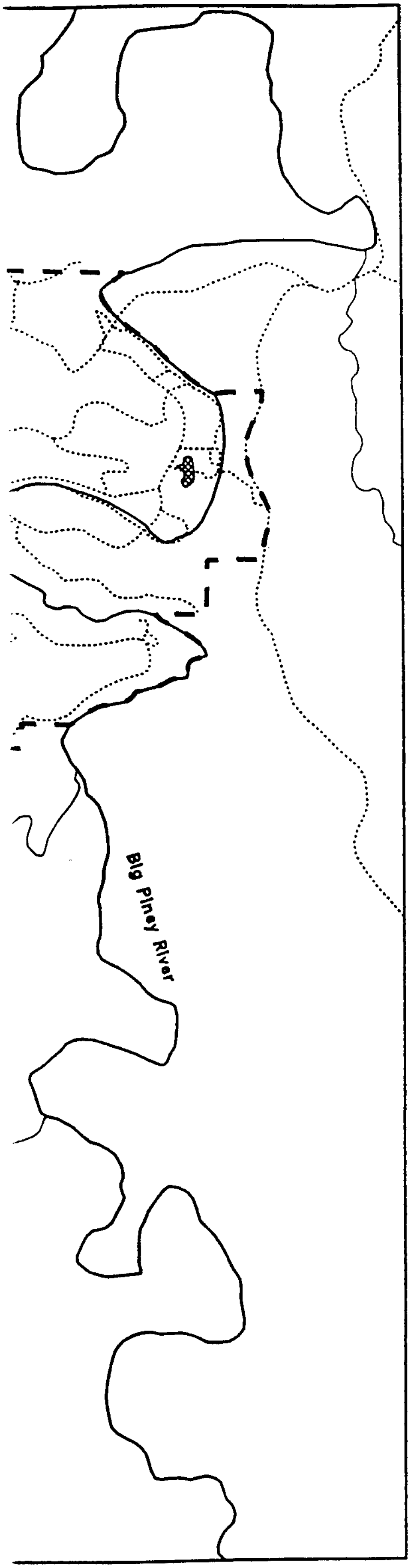


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 4–4. Indiana bat hibernacula and proposed fog oil smoke training areas at Fort Leonard Wood, Missouri.

▲ Indiana Bat Hibernaculum

Indiana Bat Hibernaculum/ Gray Bat Cave

Mobile Smoke Training Area

Mobile Smoke Deployment Road

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers

0 2 4

3D/ENVIRONMENTAL

TABLE 4-4. Proposed fog oil use at mobile and static training areas. The amount of fog oil to be used at each mobile smoke training area is described in Appendix IV, Attachment I, Table I-5.

	Training Activity*		
	7.2 Static Training	7.3 Mobile Operations	7.4 Mobile Field Training
Maximum number of generators	20	12	12
Maximum gallons fog oil per year	8500	20,000	56,000
Maximum gallons fog oil per day	----- 1200 gallons total from all sources-----		
Fog oil production rate per generator (gpm)	0.66	0.66	0.66

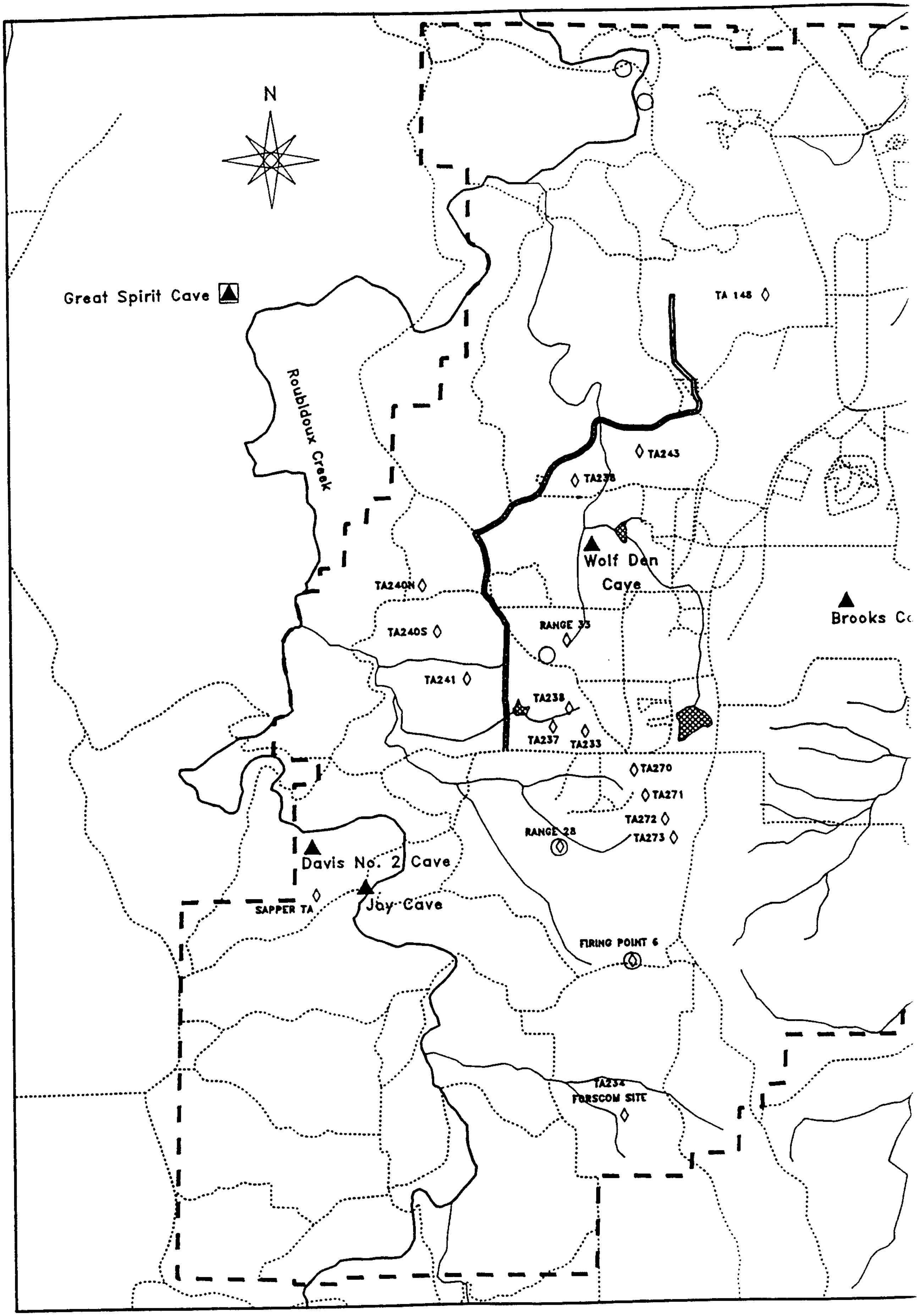
*-see Table 3.1 (HBA 1996)

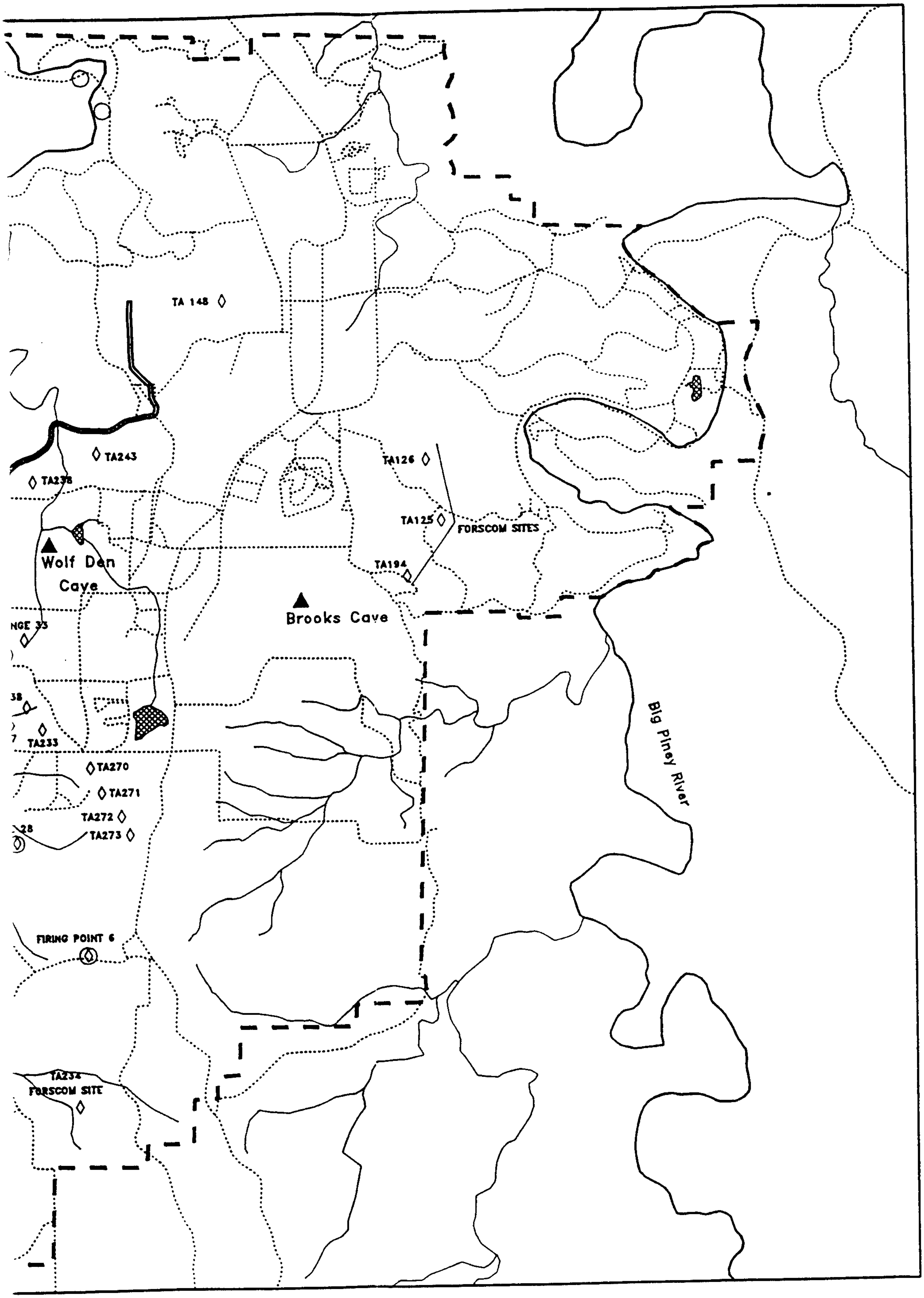
Terephthalic acid smoke grenades (M83) will be used at 22 sites across the Installation. TPA smoke pots will be used at the 4 mobile smoke training areas (Figure 4-4) and 5 smoke pot training sites (Figure 4-5). The frequency and magnitude of use varies by TPA device (Table 4-5).

Prey species are unlikely to be affected by exposure to TPA through aquatic pathways. The primary combustion products of TPA are carbon monoxide, carbon dioxide, sulfur dioxide,

TABLE 4-5. Proposed TPA smoke grenade and smoke pot use on Fort Leonard Wood. TPA grenades will be used in Training Activities 1.2, 1.4, 1.7, 4.3, 4.4, 6.1, 6.2, and 6.4. TPA smoke pot use is proposed in Training Activities 1.2, 7.3, and 7.4. See Table 3.1 (HBA 1996).

Device	Maximum Daily Number	Expected Number	Frequency of Use/Year
Smoke grenade release at any time	141	3136 per year	131 days
Smoke grenades to be released from November 1 - March 15	141	2242 from November 1 - March 15	93 days
Smoke pot	59	950 per year	16 days


N
Great Spirit Cave
Roubidoux Creek
TA 148
TA243
Wolf Den Cave
Brooks Cc
TA240N
TA240S
RANGE 33
TA241
TA238
TA237
TA233
TA270
TA271
TA272
TA273
RANGE 28
Davis No. 2 Cave
SAPPER TA
Jay Cave
FIRING POINT 6
TA234
FORSCOM SITE



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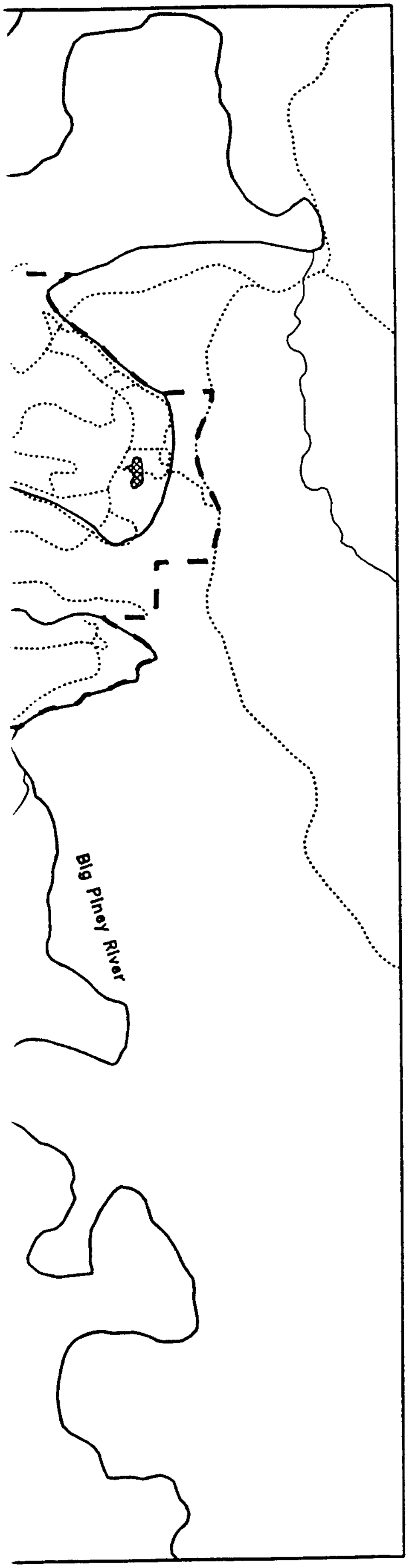


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 4-5. Indiana bat hibernacula and proposed smoke pot and smoke grenade training locations at Fort Leonard Wood, Missouri.

▲ Indiana Bat Hibernaculum

Indiana Bat Hibernaculum/ Gray Bat Cave

○ Smoke Pot Use Area

◊ Smoke Grenade Use Area

Smoke Grenade Training Road

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers
0 2 4

3D/ENVIRONMENTAL

benzene, toluene, and formaldehyde. These compounds are released in a gaseous state. It is very unlikely they will accumulate in soil or water because they volatilize and are transformed by photochemical reactions. If small quantities enter groundwater or surface water systems, they will be biodegraded by microorganisms. The particulate matter of TPA may be removed from the atmosphere by dry or wet deposition. TPA is relatively insoluble in water, but certain combustion products may enter water systems. Quantities that enter water systems (i.e. groundwater or surface water) will be rapidly degraded through photochemical reactions or through biodegradation as TPA is an organic acid that many terrestrial and aquatic microorganisms can use in metabolic processes.

Titanium Dioxide

Titanium dioxide is the major component of M82 grenades, used to simulate brass grenades. Titanium dioxide grenades produce particles that obscure troops and equipment from infrared detection. These grenades will be used at 22 sites across the Installation (Figure 4-5). Approximately 48 grenades will be used per year, with no more than 24 grenades used per day at any location. Training will occur approximately 2 days each year.

4.2 EFFECTS ANALYSIS AREA

Effects of the proposed action on Indiana bats are assessed within the Fort Leonard Wood boundary. Where effects extend beyond the Installation boundary, impacts to Indiana bats or important Indiana bat habitat are addressed.

4.3 AFFECTED HABITAT DESCRIPTION

A detailed description of the physical environment on the Installation, including topography, physiology, climate, geology, seismicity, soils, air quality, water resources, and vegetation is contained in Section 5 of the Environmental Assessment of the Master Plan and Ongoing Mission (Harland Bartholomew and Associates 1995). The description of these resources is incorporated by reference. Additional information is included in Section 4.1 of the Appendix IV to this BA.

3D/Environmental (1996a) describes Indiana bat hibernacula, and habitat surrounding the caves in Section 4.3 of the Ongoing Mission BA. The descriptions are incorporated by reference.

4.4 STUDY METHODS

4.4.1 Effect of BRAC-Related Construction to Indiana Bat Summer Habitat

3D/Environmental investigated habitat within proposed construction areas (Figure 4-2). We used a habitat suitability index model (Rommé et al. 1995) to assess suitability of proposed construction areas to support summer foraging and roosting of Indiana bats. Habitat variables important to summering Indiana bats were described for forested areas to be cleared.

Evaluated using the Indiana bat HSI model, the following habitat variables were assessed at construction sites:

- percent overstory canopy cover,
- average diameter at breast height (dbh) of overstory canopy trees,
- density of trees greater than 22 cm dbh,
- density of trees greater than 22 cm with exfoliating bark (suitable roost trees),
- percent vegetation cover from 2 m to bottom of overstory canopy,
- percent of trees 5 to 12 cm dbh,
- distance to permanent water, and
- percent forest cover within 1 km of study site.

Habitat variables were measured within nested circular plots (0.05 acre and 0.0167 acre). We sampled 3 plots per forested acre. Representative sample sites were subjectively selected within each proposed construction site.

3D/Environmental calculated the habitat suitability (HSI) of construction sites based upon measured habitat variables. The HSI is a numerical index between 0.0 and 1.0 (0 = no value, 1 = optimal). Habitat quality (HSI) and quantity (acres) were evaluated to determine the number of habitat units (HU) impacted by projects.

4.4.2 Effect of BRAC-Related Sound on Hibernating Indiana Bats

We measured and recorded sound from BRAC-related training activities. We examined the potential impacts of BRAC-related sound on hibernating Indiana bats by presenting recordings of training activities to 3 groups (replicates) of little brown bats (*Myotis lucifugus*)

hibernating under laboratory conditions. Little brown bats served as a model (surrogate) species for Indiana bats. The assumption that little brown bats and Indiana bats are similar in their response to auditory stimuli is supported by several aspects of the biology of both species. They are similar in size and morphology. The species share hibernacula and often roost near each other, although different microclimates are selected (Henshaw 1965). Echolocation signals of the two species are similar in their frequency range and peak frequencies (Fenton and Bell 1981). Audiograms (measures of hearing ability) for little brown bats indicate the frequency of greatest auditory sensitivity is near the peak frequency (frequency with the greatest energy) of the echolocation signal (Henson 1970). Although audiograms are not available for Indiana bats, we assume a similar relationship with their echolocation signals and thus a similar hearing ability to little brown bats.

The experiment was replicated with 3 groups of bats (i.e., sounds were presented to one group of bats, the bats were released, sounds were presented to a second group of bats, etc.). For each replicate, sixteen little brown bats were collected from a cave in Lawrence County, Indiana. Hibernating bats were removed from cave ceiling roosts by hand and placed in a cloth bag. Sex of each individual was determined. Right forearm length was measured to the nearest 0.5 mm, and weight to the nearest 0.1 g. A colored, numbered, split-ring plastic band was placed on the forearm for individual identification. After each bat was measured and banded, it was placed in a transportation box designed to minimize stress during transport (Kurta and Fujita 1988). The transportation box was placed on moistened foam rubber in a thermoelectric cooler maintained at 8°C. Bats were transported from the cave and placed in roost cages in hibernation chambers within approximately 4 hours of their capture. Allocation of individuals to experimental or control conditions was random. Each group of 16 bats was maintained in the laboratory for 7 days before sound presentations began.

We designed and constructed a special laboratory to study potential effects of sound on hibernating bats. The laboratory (Figure 4-6) was designed to attenuate extraneous noise sources while providing conditions to support hibernating bats and sound stimuli presentations. The interior of the laboratory was a thermally insulated, near-anechoic chamber.

Control and experimental hibernation chambers were established on opposite ends of the laboratory. In the control hibernation chamber, 6 bats were maintained in individual roost cages. These bats were isolated from sound stimuli. We monitored body surface temperature

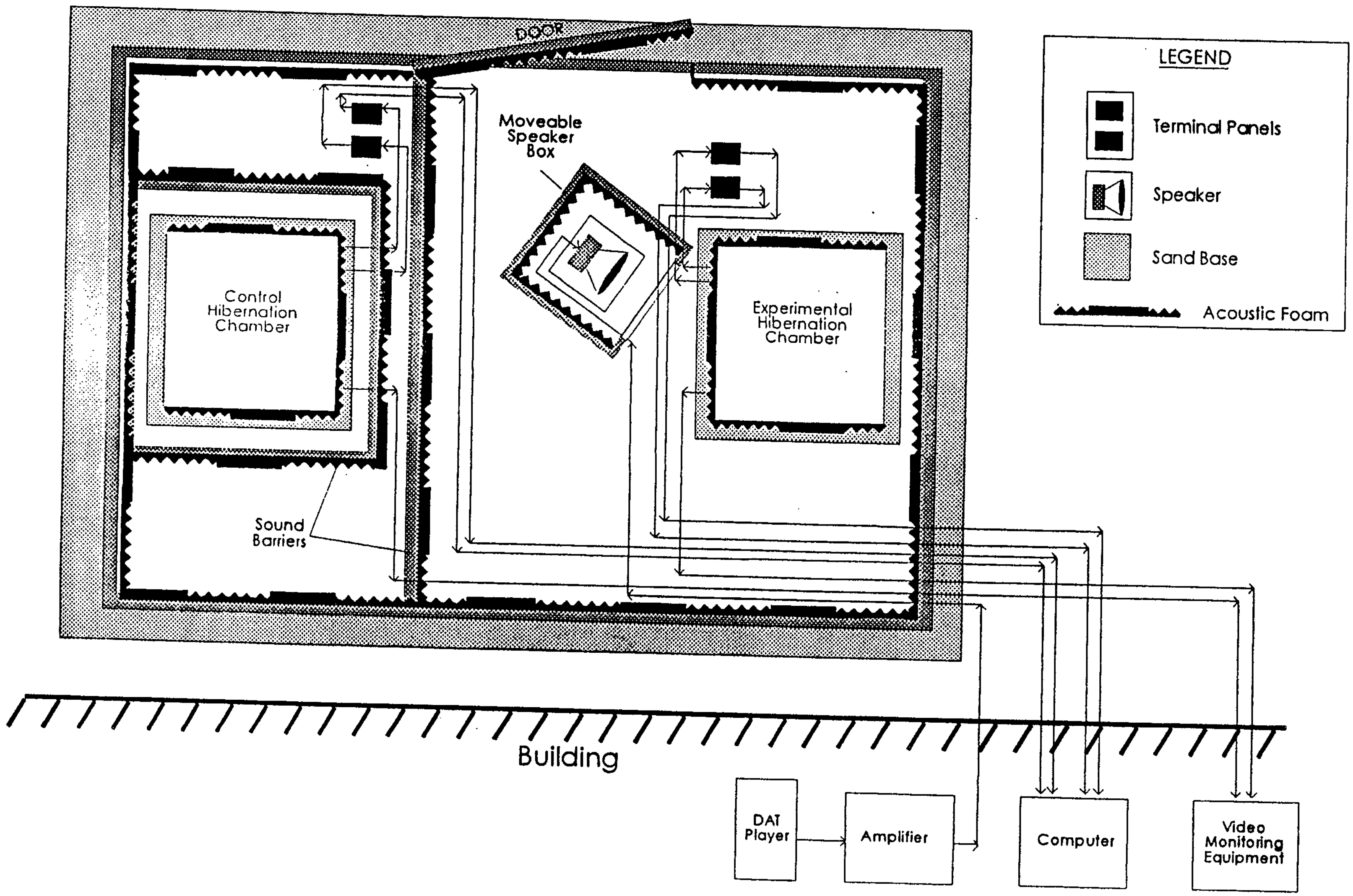


FIGURE 4-6. Laboratory constructed to determine effects of BRAC-related sound on hibernating Indiana bats at Fort Leonard Wood, Missouri. Control hibernation chamber was acoustically isolated from experimental hibernation chamber by two sound barriers.

of control bats to document patterns of arousal in the absence of experimental sound stimulation.

Ten bats in the experimental hibernation chamber received stimuli to determine whether sound representing BRAC-related training activities caused hibernating bats to arouse (Figure 4-7). Stimuli are described below. Hibernation roost cages were triangular in shape and constructed of acrylic. Cages were lined on two surfaces with plastic mesh that provided a surface from which bats could hang. Two Type T thermocouples were placed in each roost chamber so that the tip protruded 2 mm above each mesh covered surface. As bats hung from the mesh, they rested against one of the two thermocouples. Water was provided in a dish in the bottom of each roost cage. Sound and air entered the roost cages through holes in the doors.

We constructed economical hibernation chambers from commercial refrigerators. Rubber seals were removed from the doors and replaced with porous foam strips to permit air exchange and eliminate pressure changes when chamber doors were opened. We isolated compressors and coils to eliminate vibration. Climatic conditions in hibernation chambers were maintained to represent natural hibernacula. Air temperatures ranged from 4°C to 8°C. Humidity varied between 70% and 90%. Humidity was maintained by a tray of water placed in the bottom of hibernation chambers. Limestone was placed in the water to facilitate temperature regulation (by providing thermal mass) and to add a natural cave odor to the chambers.

Recordings of training activities made in the field were used as stimuli. Methods used to record sounds are described in Section 4.4.5.1 of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). These methods are incorporated by reference. We made the following assumptions regarding stimuli:

1. Recordings of activities on Range 1 represented sound generated on Range 3 and Range 6.
2. Sounds generated by construction activities are represented by recordings from TA 244.
3. Detonation of 40 mm grenades and claymore mines on Range 10 are represented by demolitions recorded on Range 38.

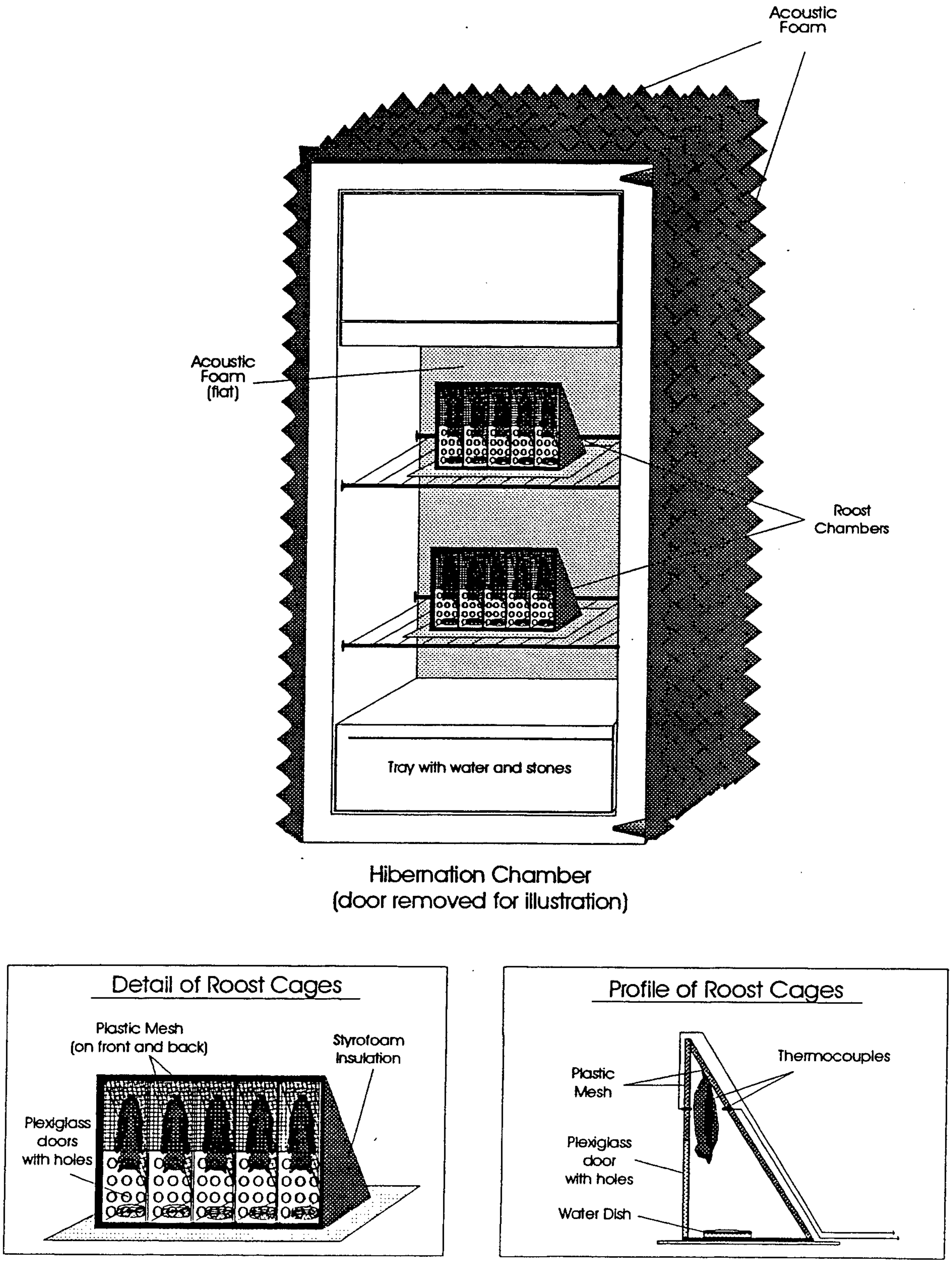


FIGURE 4-7. Hibernation chamber used for exposing hibernating bats to BRAC-related sound stimuli. An infrared video camera (not shown) was mounted in front of lower group of roost cages.

Seven sound stimuli (recordings) were presented to 10 bats per replicate (experimental subjects). Sound recordings used as stimuli are presented in Table 4-6. Smoke generator (M56 and M157) recordings were made at Edgewood Area, Aberdeen Proving Ground, Maryland. MOUT and Air Force Base Recovery recordings were made at Fort McClellan, Alabama. All other recordings were made at Fort Leonard Wood. Ten minutes was chosen as a reasonable duration because it was not feasible to present the variety of possible duration of different training activities.

Recordings presented represented worst-case conditions (i.e. the highest sound pressure level of a particular sound reaching any hibernaculum). Sound level was determined for the worst-case distance (i.e. closest) from a particular stimulus to a hibernaculum. Methods used to model sound propagation (25 Hertz (Hz) to 20,000 Hz) are described in Section 4.4.5.4 of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). These methods are incorporated by reference. Sound propagation was modeled during different weather conditions using combined sound levels for those activities with multiple sources. For example, mobile smoke training areas operate several smoke generators at one time. Sound levels are increased when more than one smoke generator is running, however the sound from two generators is not "twice as loud" as one generator (i.e., the relationship is not strictly additive). For mobile smoke training areas, we assumed 12 generators running simultaneously. Because recordings and measurements were made of sound produced by a single generator, we used standard methods for addition of sound levels (Harris 1991) to determine at source overall sound pressure levels for 12 generators. Likewise, the siren on the mobile command vehicle, the generator and blower, and the light decontamination apparatus from Air Force Base Recovery training were combined.

Sound propagation modeling incorporates the frequency spectrum of sounds measured. We conducted a spectrum analysis of sound generated by MOUT training and found only frequencies up to 4000 Hz were detectable at 65 m. Other BRAC-related sound contained frequencies from 25 Hz to 20,000 Hz. Sound propagation modeling for 25 Hz to 20,000 Hz was completed for the ongoing mission biological assessment (3D/Environmental 1996a). Sound propagation modeling for 25 Hz to 4000 Hz was completed for this analysis.

TABLE 4-6. Duration and sound levels of stimuli presented to hibernating little brown bats in the laboratory.

Stimulus	Duration (min)	Sound Level Presented (dB SPL)
Range 4 - Night Infiltration Training	10	70
TA 244 - Construction Equipment	10	65
Range 3 and Range 6 - Small Arms	10	73
Range 10 - Mines and Grenades	7	115
M56 Smoke Generator	10	68
M157 Smoke Generator	10	65
Military Operations in Urbanized Terrain (MOUT) - Small Arms	10	65
Babb Airfield - Air Force Base Recovery	10	65
Presentation Control	10	0

Stimuli (Table 4-6) were presented to experimental bats with a digital audio tape (DAT) player, 300 watt amplifier, and 200 watt speaker. The speaker was too large for installation inside the hibernation chamber so the door to the hibernation chamber was opened during presentations. The large speaker was chosen because of its superior low frequency response. The protocol for stimulus presentations was as follows: The tape player and amplifier were turned on and adjusted to appropriate settings for the desired sound level. The hibernation chamber door was opened and the speaker moved into position. The stimulus was played for 10 min, the speaker was removed, and the door to the hibernation chamber closed. Because this procedure could have created a disturbance and caused a temporary increase in hibernation chamber temperature, a control stimulus was also presented to experimental bats which included all activities associated with stimulus presentations except sound. A double layer of black felt was suspended over the front of the interior of the experimental hibernation chamber to maintain the temperature and eliminate visual disturbance during stimulus presentations.

Following a 7-day acclimation period, one stimulus was presented each day between 1530 h and 1630 h. The order of presentation was randomized for each replicate (i.e., the stimuli were not presented in the same order for each replicate).

Experimental and control study animals were returned to their hibernaculum following an experimental replicate. In the first replicate, one bat escaped from its hibernation cage and was not found. Another died after becoming trapped in the door of the cage. They were the only mortalities during the study. On subsequent collection trips to the hibernaculum, many banded individuals from previous replicates were observed in apparent good health.

Surface body temperatures for control and experimental bats were plotted for each day of the experiment. We examined each plot to determine whether individual bats aroused from hibernation. Because we were interested in unnecessary energy expenditures, we conservatively defined an arousal when a bat's surface temperature remained one degree (°C) or more above the air temperature for greater than 30 min. A natural arousal of a control bat is shown in Figure 4-8.

We assessed short-term and latent responses. Short-term responses were assessed by examining temperature charts for experimental bats during the 4-hour period following a stimulus presentation. The analysis window was extended to the 8-hour period following a stimulus presentation to include latent responses (Thomas 1995). Because arousals occur naturally and circadian rhythms for arousals have been shown in some species (Twente and Twente 1987), we calculated an expected number of arousals for control and experimental bats for these post-stimulus periods. Expected results (assuming no difference between control and experimental) were calculated by averaging the observed experimental and control arousals. For each stimulus presentation, we compared the observed and expected number of arousals for each post-stimulus period. Our null hypothesis predicted no difference between observed and expected. Significant differences (chi-square, 1 d.f., $p < 0.05$) between observed and expected numbers of arousals would be attributed to experimental stimuli. Because of the small sample sizes, Yates correction factor for continuity was applied. An interaction chi-square analysis (Zar 1984) indicated data were homogeneous among replicates and could be pooled. Pooled chi-squares were conducted for each stimulus.

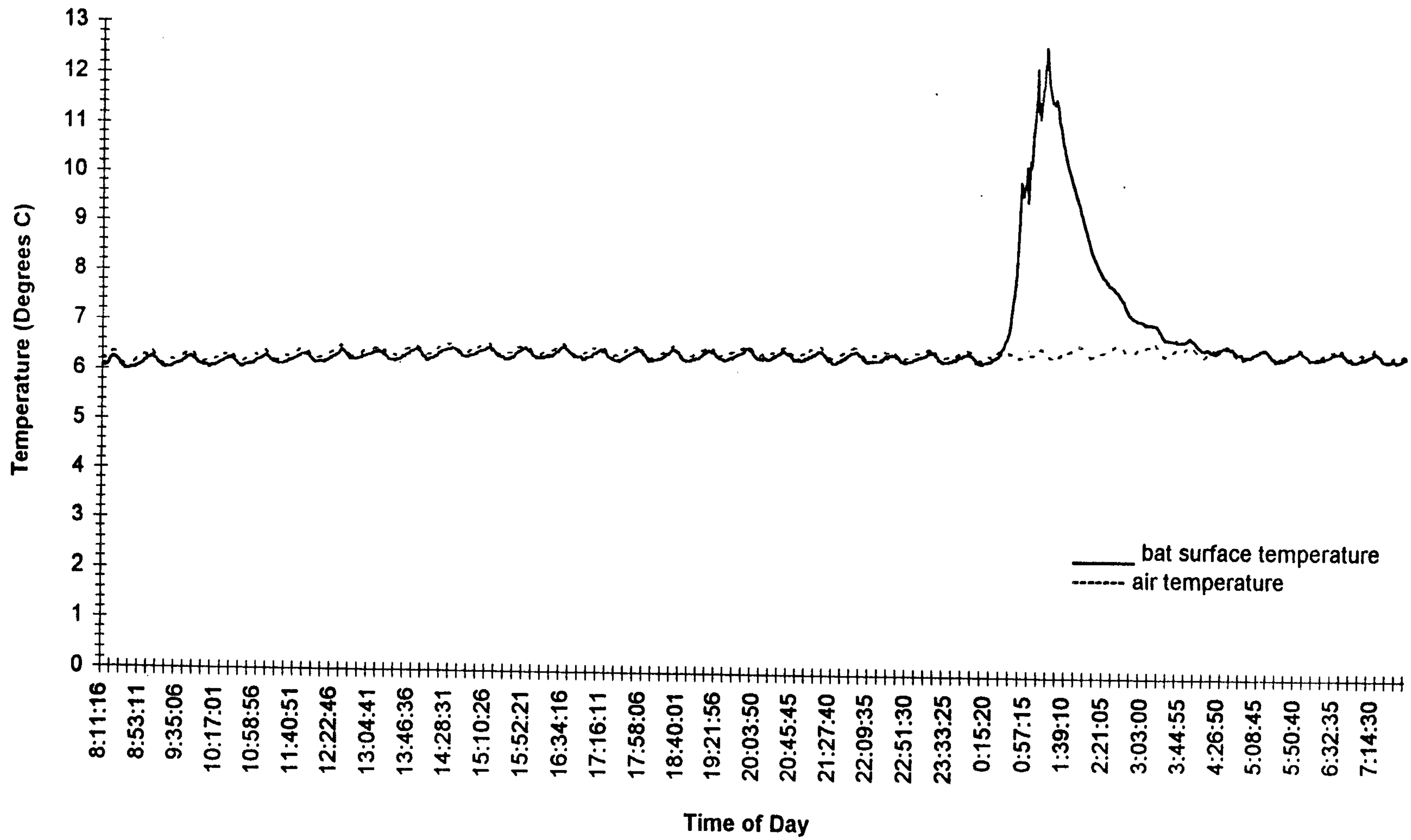


FIGURE 4-8. Temperature chart showing a natural arousal of a control bat. Similar temperature charts would be exhibited by experimental bats if arousals were observed following presentation of BRAC-related sound stimuli.

Infrared-sensitive video cameras were used to monitored bat behavior during the experiment. One camera monitored 3 control bats while another monitored 5 experimental bats. Bats' behavior was continuously recorded with a time-lapse video recorder. We used video monitoring to detect immediate responses (e.g., startle) to presented stimuli which might not be detectable with body temperature monitoring.

4.4.3 Effect of Toxicological Agents

A detailed description of methods used to assess toxicological effects to receptors is provided in Appendix IV. In general, receptors were characterized by reviewing available information describing seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history (Appendix IV, Section III).

Descriptions of pertinent information regarding the study site were prepared. Local geomorphology, soils, groundwater, surface water, climate, natural resources were characterized (Appendix IV, Section IV).

Information describing evaluated substances was gathered. Chemical composition, physical properties, anticipated location and frequency of use, anticipated environmental transformation and stressor transport, and environmental fate were evaluated (Appendix IV, Section V). The toxicity of potential stressors through inhalation, ingestion, and dermal absorption was described (Appendix IV, Section VII).

Indiana bat hibernacula and gray bat maternity caves on FLW were mapped, and climatic conditions in the caves were characterized using sophisticated meteorological equipment. Data collected were used to model the movement of airborne contaminants into and out of the caves (Appendix IV, Section VI). No mapping or meteorological information was collected for Great Spirit Cave. Effects to Indiana bats and gray bats at Great Spirit Cave were assessed based on contaminant concentrations expected to reach the cave.

3D/Environmental evaluated air dispersion models (ISC 3.0, INPUFF 2.3, and TREMS1) for use in predicting movement of airborne substances from their source to receptors (Appendix IV, Section VI). The TREMS1 model was selected for application in

this BA. Dispersion and deposition of stressors in various atmospheric stabilities were mapped (Appendix IV, Section VIII).

The potential for receptors to be exposed to stressors was characterized (Appendix IV, Section VIII). Selected substances were eliminated from detailed evaluation if a complete exposure pathway was not present (Appendix IV, Section VIII). Other substances were eliminated from detailed analysis due to their low toxicity, or the limited quantity to be used (Appendix IV, Attachment A).

We calculated the amount of stressor receptors will intake during single training events (acute intake) and during repeated exposures over their lifetime (chronic intake). The potential for acute and chronic exposures was calculated (Appendix IV, Section IX). Where specific information describing proposed training, receptors, or contaminants was not available, assumptions were critical in characterizing risks (Appendix IV, Section X). Effects to receptors are expected where the anticipated exposure exceeds safe levels. Effects are indicated by Hazard $\text{Quotient}_{\text{acute}}$ or Hazard $\text{Quotient}_{\text{chronic}}$ greater than 1.0 (Appendix IV, Section IX).

4.5 RESULTS

4.5.1 Effects of BRAC-Related Construction to Indiana Bat Summer Habitat

Approximately 42,580 acres of forested land occur within Installation boundaries. Construction activities for 17 of the 56 proposed projects remove 178 acres of forested habitat (Tables 4-7 and 4-8). Forest at construction sites provides suitable foraging habitat, but quality of roosting habitat at most sites limits overall habitat suitability (Table 4-8). Construction activities at 12 sites require removal of currently suitable roost trees. The mean density for high, moderate, and low quality suitable roost trees at portions of the 12 sites containing suitable roost trees is 1.7/acre (n=226), 1.7/acre (n=224), and 1.5/acre (n=300) respectively. Optimal habitat, as defined by the Indiana bat HSI model provides over 5 suitable roost trees per acre (Rommé et al. 1995).

TABLE 4-7. Location, acreage, and quality of Indiana bat summer habitat to be affected by construction to support BRAC activities at Fort Leonard Wood, Missouri. Numbers in the "Map Label No." column correspond with locations on Figure 4-2.

Project Requirements	Map Label No.	Proposed Location	Acreage and Quality of Forest to be Removed
Cantonment Projects			
Base Operations Administration	100	Renovation inside Lincoln and Hoge halls	No Tree Clearing - Open Fields
Chemical, Administration	101	New Construction north of Lincoln Hall	No Tree Clearing - Open Fields
Chemical, FOX Maintenance and Maintenance Training	102	Renovation of Building 5265	No Tree Clearing - Renovation Only
Chemical FOX Organizational Vehicle Parking	103	Construct fenced parking area near Training Area 250	No Tree Clearing
Chemical, Library	100	Located at Clark Hall	No Tree Clearing - Renovation Only
Chemical, Museum	104	New Construction, Museum addition to Walker Museum	No Tree Clearing - Mowed Area
Chemical, NCO General Instruction	101	New Construction, NCOA included in General Instruction Facility north of Lincoln Hall	No Tree Clearing - Open Fields
Chemical, Officer General Instruction	101	New Construction north of Lincoln Hall	No Tree Clearing - Open Fields
Chemical, OSUT (DATF)	105	New Construction, Chemical DATF located north of South Dakota Avenue, west of Alabama Avenue, and west of the 800 Area barracks	3 acres of Moderate Quality Habitat
Housing, Enlisted Barracks (reallocation)	106	Reallocation of existing barracks: 600-700 Engineer OSUT; 800 MP OSUT; 700 Chem OSUT; south Speacker to ITRO; north Speacker to junior Perm Party, Diversion of Indiana Street Housing	No Tree Clearing - Existing Buildings
Housing, Enlisted Barracks (new construction)	101	New Construction, New barracks north of the General Instruction Facility addition to Lincoln Hall	1.0 acre of Low Quality Habitat and 1.4 acres of Moderate Quality Habitat
Housing, Enlisted Dining (reactivation)	107	Reactivation of dining facility at Speacker	No Tree Clearing - Existing Buildings
Housing, Enlisted Dining (new construction)	101	New Construction, Construction of Dining Facility at barracks north of Lincoln Hall	No Tree Clearing - Open Fields

TABLE 4-7. Continued.

Project Requirements	Map Label No.	Proposed Location	Acreage and Quality of Forest to be Removed
Housing, General Officers Quarters (GOQ)	108	New Construction, Northeast side of Piney Hills Drive	1.4 acres of Moderate Quality Habitat
Housing, Officer Unaccompanied (UOQ)	109	Renovation of Sturgis Heights UPH(O)s, Diversion of Indiana Street Housing	No Tree Clearing - Renovation Only
Military Police, Administration	101	New Construction north of Lincoln Hall	No Tree Clearing - Open Fields
Military Police, Library	100	Located at Clark Hall	No Tree Clearing - Renovation Only
Military Police, Museum	104	New Construction, Museum addition to Walker Museum	No Tree Clearing - Mowed Area
Military Police NCO General Instruction	101	New Construction, NCOA included in General Instruction Facility north of Lincoln Hall	No Tree Clearing - Open Fields
Military Police, Officer General Instruction	101	New Construction north of Lincoln Hall	No Tree Clearing - Open Fields
Military Police, OSUT	110	New Construction, located southwest of the 800 Area	7.5 acres of Moderate Quality Habitat
Vehicle and Equipment (Organizational), Maintenance in the Cantonment	111	Assign an existing unit maintenance facility (with parking area) to the 11th Chemical Company. Maintain the remaining vehicles at existing Directorate of Logistics Maintenance facilities.	No Tree Clearing - Existing Facilities
Vehicle and Equipment (Organizational), Maintenance outside of the Cantonment	205	Construct a new maintenance facility for the Military Police vehicles used in Evasive Driving Training near the training area.	No additional tree clearing - included in Evasive Driving Training area analysis.
Vehicle and Equipment (Organizational), Parking/Storage in the Cantonment	111	Assign an existing unit maintenance facility (with parking area) to the 11th Chemical Company. Maintain the remaining vehicles at existing Directorate of Logistics Maintenance facilities.	No Tree Clearing - Existing Facilities

TABLE 4-7. Continued.

Project Requirements	Map Label No.	Proposed Location	Acreage and Quality of Forest to be Removed
Vehicle and Equipment (Organizational), Parking/Storage outside of the Cantonment	205	Construct a new maintenance facility (with parking area) for the Military Police vehicles used in Evasive Driving Training near the training area.	No additional tree clearing - included in Evasive Driving Training area analysis.
Warehouse/ Storage	112	New Construction requirement temporarily deferred through the renovation of buildings 2310 and 2311	No Tree Clearing - Renovation Only
Soil Disposal Area	101	Excess soil from construction will be placed in a gulley south of the Housing, Enlisted Barracks	2.85 acres of Moderate Quality Habitat
Range Modification Projects			
16 Building MOUT	200	New Construction, North of Babb Airfield	0.8 acre of Moderate Quality Habitat and 3.2 acres of Low Quality Habitat
Chemical Defense Training Facility (CDTF)	201	New Construction near TA 246, southwest of the Airfield and northeast of Normandy Training Area	19.67 acres of Moderate Quality Habitat and 2.5 acres of Low Quality Habitat
9mm Pistol (FATS Simulator)	202	New Construction at Range 21	No Tree Clearing - Mowed Area
Air Force Base Recovery	203	New Construction at Babb Airfield	No Tree Clearing - Mowed Airstrip
Air Force Gas Chamber	204	New Construction at TA 101	No Tree Clearing - Open Field
Evasive Driving	205	New Construction at TA 109A	5.0 acres of Moderate Quality Habitat
Flame Range	206	New Construction at Range 27A	4.3 acres of Moderate Quality Habitat
FOX Vehicle Swim	103	New Construction at TA 250	No Tree Clearing
HMMWV Driving	205	New Construction at TA 109A	No Tree Clearing - Open Field
M60 Range	207	New Construction, Overlay at Range 18	No Tree Clearing - Open Field
Marine 9mm Pistol	208	New Construction, Overlay at Range 17	0.1 acre of Low Quality Habitat
Marine Combat Pistol	208	New Construction, Overlay at Range 17	No Additional Clearing - Combined with Marine 9mm Pistol

TABLE 4-7. Continued.

Project Requirements	Map Label No.	Proposed Location	Acreage and Quality of Forest to be Removed
Marine NBC Training	204	New Construction, Overlay at TA 101	0.5 acre of Low Quality Habitat
Marine Shotgun	208	New Construction, Overlay at Range 17	No Additional Clearing - Combined with Marine 9mm Pistol
Mobile Smoke Training Areas	209	Cannon Range	No Tree Clearing - Existing Roads
	210	Ballard Hollow	1.0 acre of Moderate Quality Habitat and 0.4 acre of Low Quality Habitat
	211	Musgrave Hollow	0.4 acre of Low Quality Habitat
	212	Bailey/McCann Hollow	4.05 acres of Moderate Quality Habitat and 2.35 acres of Low Quality Habitat
Mark 19 Familiarization Range	213	New Construction, Overlay at Range 19	100 acres of Moderate Quality Habitat and 15 acres of Low Quality Habitat
Mark 19 Qualification Range	207	New Construction, Overlay at Range 18	No Tree Clearing - Open Field
Special Reaction Team Marksman/ Observer Range	214	New Construction at Ranges 15	No Tree Clearing - Open Field
Special Reaction Team Range	214	New Construction, Overlay at Range 15	No Tree Clearing - Open Field
Static Smoke Training Area	215	New Construction at Range 30	0.25 acre of Low Quality Habitat
Static Smoke Relocate Range 30 Day/Night	216	New Construction, Overlay at Range 11	No Tree Clearing - Open Field
Static Smoke Relocate Range 29	217	New Construction, Overlay at Range 4	No Tree Clearing - Open Field
Static Smoke Relocate Range 30F	218	New Construction, Overlay at Range 6	No Tree Clearing - Open Field
Range Support Addition	219	New Construction near Range Control	1.4 acres of Low Quality Habitat
Small Arms Range	220	New Construction, Overlay at Range 3	No Tree Clearing - Open Field
Mark 19 / US Weapons	221	New Construction, Overlay at Range 10	No Tree Clearing - Open Field

TABLE 4-8. Habitat suitability index analysis of proposed BRAC project requirements that impact forested habitat. For each requirement the number of forested acres to be cleared, and suitability of roosting habitat (LRSI Roosting), foraging habitat (LRSI Foraging), and overall summer habitat (HSI) is indicated. Habitat units affected by each project are provided (HU). HSI and HU are quality values with 0 equaling no value and 1.0 equaling optimal value. The associated map label numbers, [#], correspond with locations on Figure 4-16.

Project Requirements	Forested Acres	LRSI Roosting	LRSI Foraging	HSI	HU
Housing, General Officer Quarters [108]	1.40	0.43	0.65	0.37	0.52
Housing, Enlisted Barracks, new [101]					
Buildings/Parking Lot	1.00	0.00	0.56	0.00	0.00
Road A	0.90	0.45	0.80	0.36	0.32
Road B	0.50	0.50	0.93	0.37	0.19
Chemical, OSUT [105]	3.00	0.33	0.86	0.28	0.84
Military Police, OSUT [110]					
Woodlot A	6.25	0.63	0.90	0.48	3.00
Woodlot B	1.25	0.57	0.77	0.43	0.54
Soil Disposal Area [101]	2.85	0.21	0.78	0.17	0.48
16 Building MOUT [200]					
Woodlot A	0.80	0.67	0.93	0.60	0.48
Woodlot B	3.20	0.00	0.34	0.00	0.00
Chemical Defense Training Facility [201]					
Facility	19.30	0.44	0.59	0.39	7.53
Pipeline	1.00	0.00	0.54	0.00	0.00
Road	1.00	0.00	0.99	0.00	0.00
Small Building NE of Facility	0.50	0.00	0.81	0.00	0.00
Powerline	0.37	0.44	0.59	0.39	0.14
Evasive Driving Course [205]					
Woodlot A	3.50	0.57	0.46	0.39	1.37
Woodlot B	1.50	0.55	0.66	0.46	0.69

TABLE 4-8. Continued.

Project Requirements	Forested Acres	LRSI Roosting	LRSI Foraging	HSI	HU
Flame Range [206]					
Trail from 27A to McCann Hollow	1.30	0.32	0.53	0.29	0.38
FFE Training Area	3.00	0.36	0.83	0.33	0.99
Marine 9mm Pistol [208]					
Buildings	0.10	0.00	0.89	0.00	0.00
Marine NBC Training [204]	0.50	0.00	0.89	0.00	0.00
Mobile Smoke - Bailey/McCann [212]					
Road A	0.60	0.52	0.70	0.47	0.28
Road B	0.90	0.61	0.70	0.51	0.46
Road C	1.75	0.00	0.62	0.00	0.00
Road D	1.05	0.55	0.91	0.37	0.39
Road E	1.50	0.37	0.62	0.26	0.39
Road F	0.20	0.00	0.69	0.00	0.00
McCann Tower	0.40	0.00	0.71	0.00	0.00
Mobile Smoke - Musgrave [211]					
Northwestern Tower	0.40	0.00	0.85	0.00	0.00
Mobile Smoke - Ballard [210]					
Road	1.00	0.46	0.69	0.41	0.41
Tower	0.40	0.00	0.40	0.00	0.00
Range Support Addition [219]	1.40	0.00	0.71	0.00	0.00
Mark 19 Familiarization Range [213]					
Woodlot A	15.00	0.00	0.79	0.00	0.00
Woodlot B	7.30	0.34	0.77	0.31	2.26
Woodlot C	39.0	0.26	0.81	0.23	8.97
Woodlot D	22.7	0.48	0.78	0.43	9.76
Woodlot E	4.00	0.43	0.74	0.39	1.56
Woodlot F	27.00	0.23	0.82	0.21	5.67
Static Smoke Range [215]					
Fuel Storage Building	0.25	0.00	0.62	0.00	0.00
Totals:	178.07				48.74

None of the forested areas evaluated with the HSI model provide both high quality roosting and high quality foraging habitat for Indiana bats (Table 4-8). HSI values ranged from 0.0 to 0.6 with a mean of 0.24 (Table 4-8). Construction will remove 48.74 Habitat Units (Table 4-8).

4.5.2 Effect of BRAC-Related Sound on Hibernating Indiana Bats

To model sound propagation from BRAC-related training ranges to Indiana bat hibernacula, measurements of peak sound levels at each sound source (i.e., on each range) were required. We measured peak sound pressure levels in decibels (dB SPL) for all sound sources examined in this study (Table 4-9). We conducted spectral and time series analyses of sounds generated by BRAC training activities. Characteristics displayed in these analyses were required for sound modeling and are provided as reference material in Appendix I of this document and Appendix I of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). All sound sources, except for MOUT training, have frequency ranges from 25 Hz to 20,000 Hz. No frequencies above 4000 Hz were measured from MOUT training.

Sound propagation under summer and winter weather conditions was modeled for mobile smoke training areass, MOUT training, and Air Force Base Recovery (Appendix II). Propagation of sound from other ranges (e.g., Range 4 and Construction Equipment) was modeled for the Biological Assessment of Fort Leonard Wood's Master Plan and Ongoing Mission (3D/Environmental 1996a). These results are incorporated by reference. Frequency specific sound propagation modeling results for MOUT training are included in Appendix III. Sound modeling results show all sounds examined can travel significant distances under appropriate weather conditions. For example, decontamination training generated a peak SPL at its source of 107 dB (Appendix II, Table 1c. 8) which was the lowest SPL of modeled sounds. On a clear, windy, winter day, the predicted sound level at 2000 m is 10 dB above background. Sound levels of stimuli presented to bats (Table 4-6) represent worst-case modeled sound levels reaching hibernacula for each source.

Results of our presentations of sound stimuli to hibernating little brown bats are shown in Tables 4-10 and 4-11. None of the experimental stimuli resulted in a statistically significant treatment effect (i.e., experimental bats did not arouse more frequently than expected).

TABLE 4-9. Peak sound pressure levels (SPLs) measured from BRAC-related sound sources proposed to be located near Indiana bat hibernacula on Fort Leonard Wood. Measurements represent peak SPLs at 0 m from the source.

Sound Source and Associated Training Range(s)	Peak Sound Pressure Level (dB SPL)
Night Infiltration Training - Range 4	142
Construction Equipment - BRAC Facilities Construction Locations	125
Small Arms - Range 6	122
Mine and Grenade Detonations	194
M56 Smoke Generator - Mobile Smoke Training Areas	122
M157 Smoke Generator - Mobile Smoke Training Areas	112
Military Operations in Urbanized Terrain - 16 Bldg MOUT	120
Siren: Air Force Base Recovery - Babb Airfield	128
Generator and Blower: AF Base Recovery - Babb Airfield	102
Light Decontamination Apparatus: AF Base Recovery - Babb Airfield	107

No immediate responses were observed on video tapes (e.g., folding of pinnae or startle). Recorded arousals showed bats awakening, becoming active for a short period of time, resting at increased body temperatures, and re-entering hibernation. We did not observe behavior which would lead us to believe bats were not in a normal state of hibernation. Quantitative analyses of video tapes have not been conducted.

4.5.3 Effect of Toxicological Agents

Information pertinent to this toxicological evaluation describing seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history are provided in Section III of Appendix IV. Descriptions of local geomorphology, soils, groundwater, surface water, climate, and natural resources are provided in Section IV of Appendix IV.

TABLE 4-10. Number of arousals recorded from experimental groups during 4-hour period following presentation of stimuli. Sound stimuli represent selected training activities under worst-case predicted conditions.

Stimulus	Number of Arousals Observed from Experimental Group in 4-hour Post-Stimulus Period (n = sample size)			Pooled Chi-square, 1 Degree of Freedom (Probability)
	Replicate			
	1	2	3	
Range 4	2 (n=9)	1 (n=10)	3 (n=10)	0.21 (0.64)
BRAC Facilities Construction	1 (n=8)	7 (n=10)	0 (n=10)	1.01 (0.31)
Range 6	0 (n=8)	3 (n=10)	0 (n=10)	0.03 (0.87)
Mines and Grenades	1 (n=8)	4 (n=10)	0 (n=10)	0.96 (0.33)
M56 Smoke Generator	1 (n=8)	0 (n=10)	5 (n=10)	0.21 (0.65)
M157 Smoke Generator	2 (n=8)	1 (n=10)	2 (n=10)	0.02 (0.88)
MOUT	NA	1 (n=10)	0 (n=10)	0.04 (0.84)
Air Force Base Recovery	0 (n=8)	4 (n=10)	0 (n=10)	0.04 (0.83)
Presentation Control	1 (n=8)	0 (n=10)	0 (n=10)	0.54 (0.46)

NA = not applicable. MOUT recording could not be obtained before first replicate.

TABLE 4-11. Number of arousals recorded from experimental groups during 8-hour period following presentation of stimuli. Sound stimuli represent selected training activities under worst-case predicted conditions.

Stimulus	Number of Arousals Observed/Expected in 8-hour Post-Stimulus Period (n = sample size)			Pooled Chi-square, 1 Degree of Freedom (Probability)
	Replicate			
	1	2	3	
Range 4	2 (n=9)	1 (n=10)	7 (n=10)	1.79 (0.18)
BRAC Facilities Construction	2 (n=8)	7 (n=10)	0 (n=10)	1.23 (0.26)
Range 6	0 (n=8)	3 (n=10)	0 (n=10)	0.00 (0.99)
Mines and Grenades	1 (n=8)	5 (n=10)	1 (n=10)	1.70 (0.19)
M56 Smoke Generator	1 (n=8)	0 (n=10)	5 (n=10)	0.10 (0.75)
M157 Smoke Generator	2 (n=8)	1 (n=10)	2 (n=10)	0.00 (0.99)
MOUT	NA	1 (n=10)	1 (n=10)	0.21 (0.65)
Air Force Base Recovery	0 (n=8)	4 (n=10)	0 (n=10)	.012 (0.73)
Presentation Control	1 (n=8)	0 (n=10)	0 (n=10)	0.79 (0.37)

NA = not applicable. MOUT recording could not be obtained before first replicate.

4.5.3.1 Fog Oil

Toxicity

Chemical properties and a general description of fog oil is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of fog oil via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when Indiana bats forage or roost during spring staging, during the summer maternity season, and during fall swarming. Indiana bats in hibernacula also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of fog oil in air, and the rate at which fog oil is deposited in various atmospheric conditions are described in Appendix IV, Section VIII. Figures 4-9 and 4-10 are representative examples of fog oil dispersion from static and mobile smoke training areas in Pasquill atmospheric stability category E. Dispersion of fog oil in Pasquill categories B - E is described and plotted in Appendix IV, Section VIII. Figures 4-11 and 4-12 are representative examples of fog oil deposition downwind of static and mobile training areas in Pasquill atmospheric stability category E. Additional estimates of fog oil deposition are provided in Appendix IV, Attachment B. Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment C.

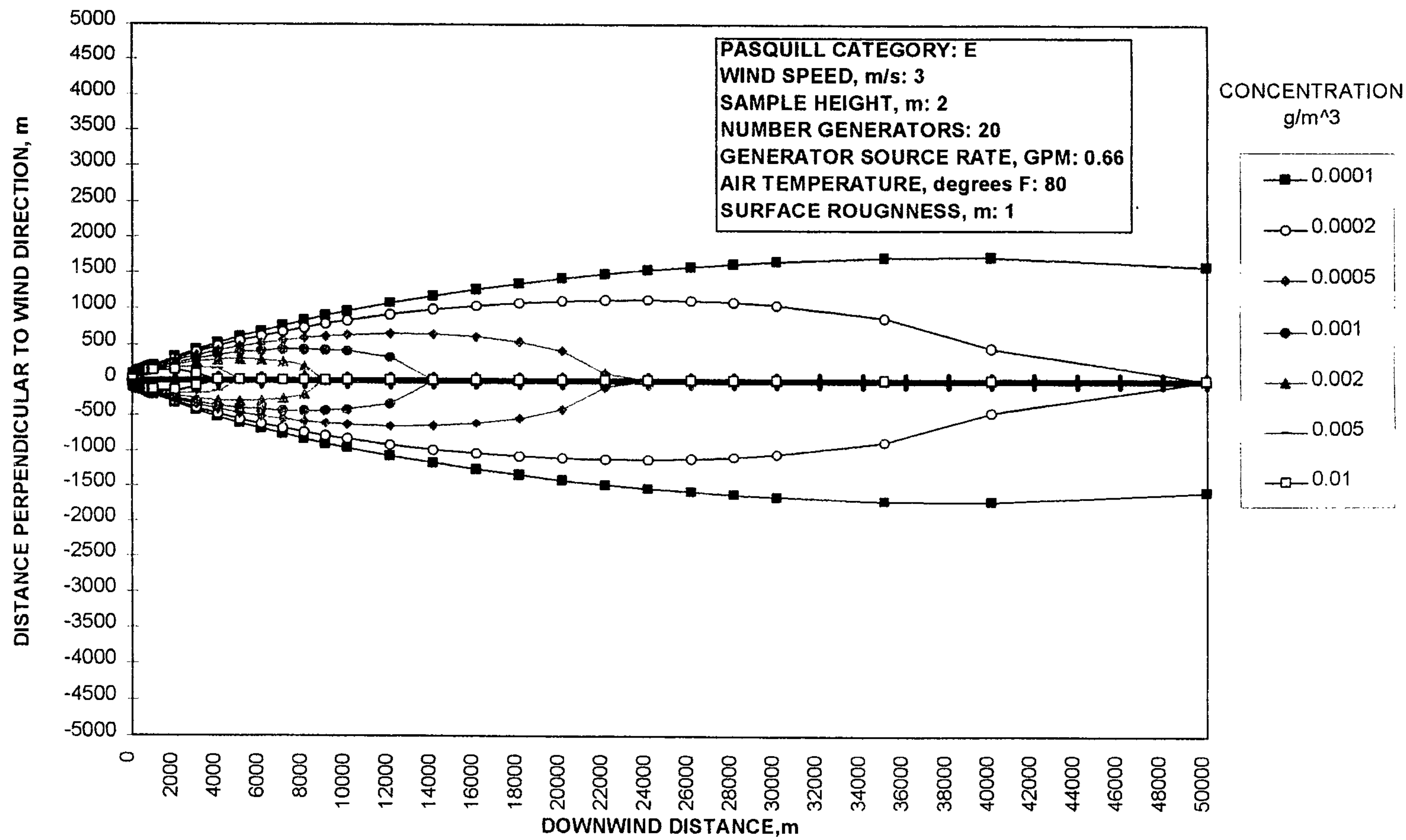


FIGURE 4-9. Concentration of fog oil smoke (Pasquill E) at varying distances from the static training area.

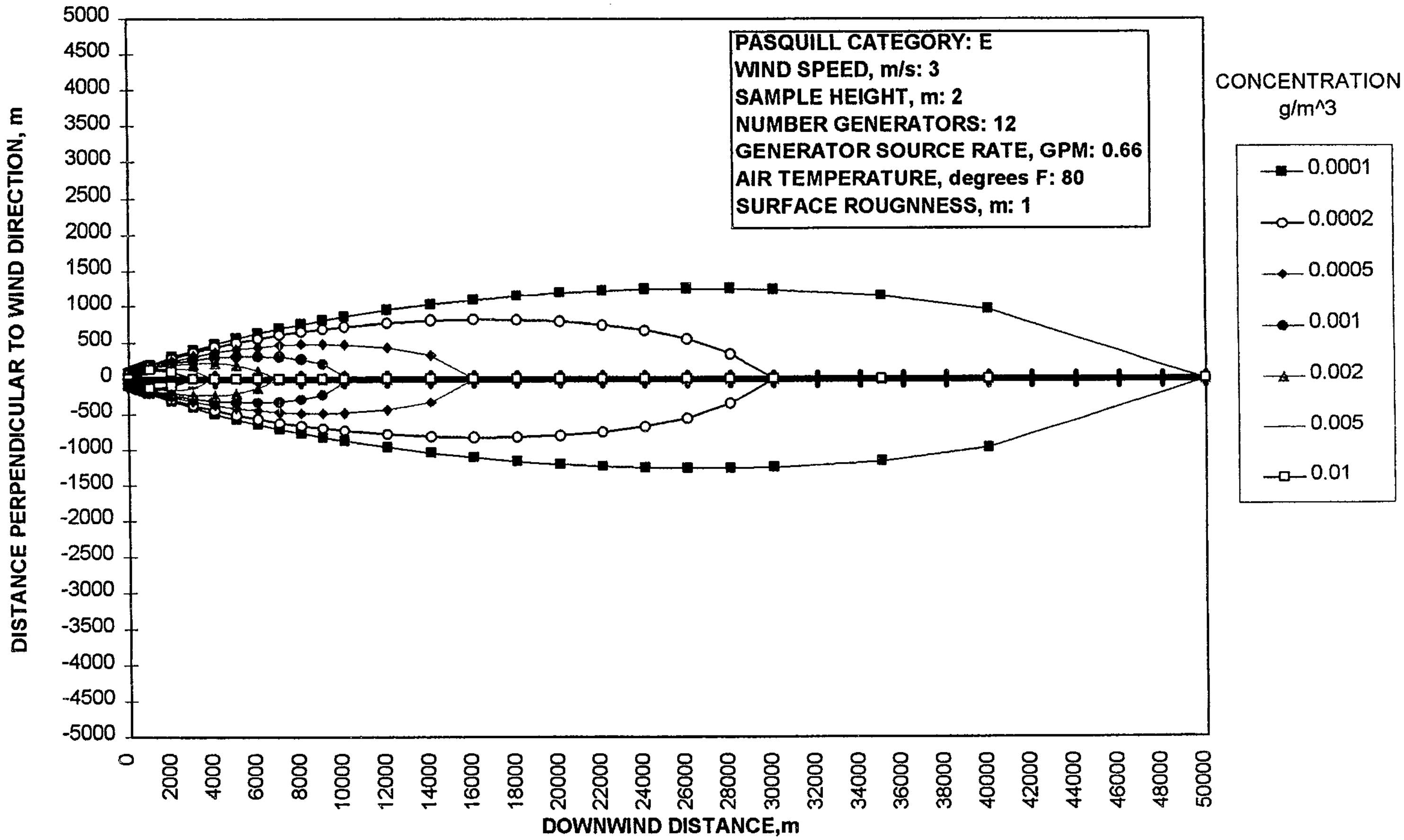


FIGURE 4-10. Concentration of fog oil smoke (Pasquill E) at varying distances from the mobile training areas.

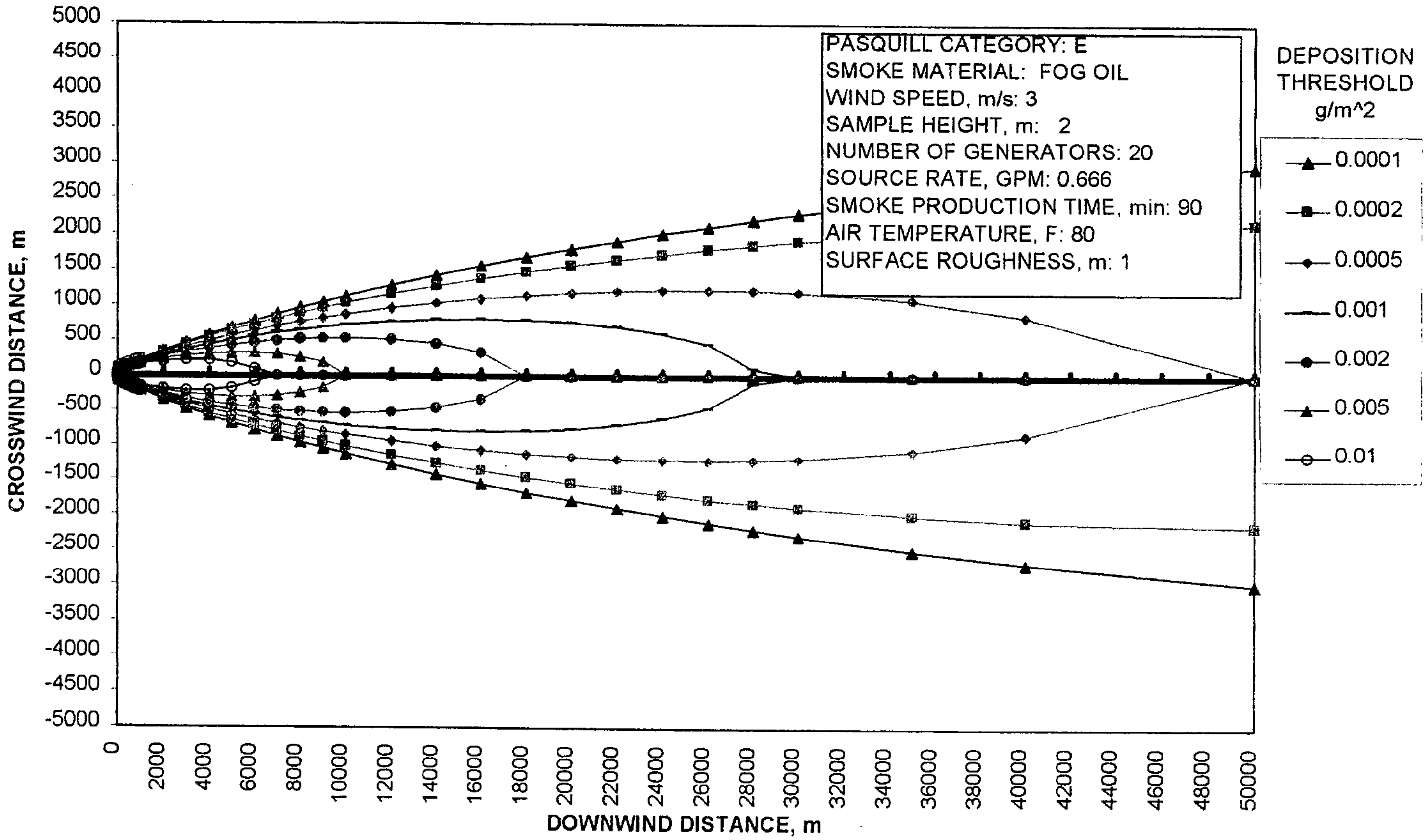


FIGURE 4-11. Deposition of fog oil smoke (Pasquill E) at varying distances from the static training area.

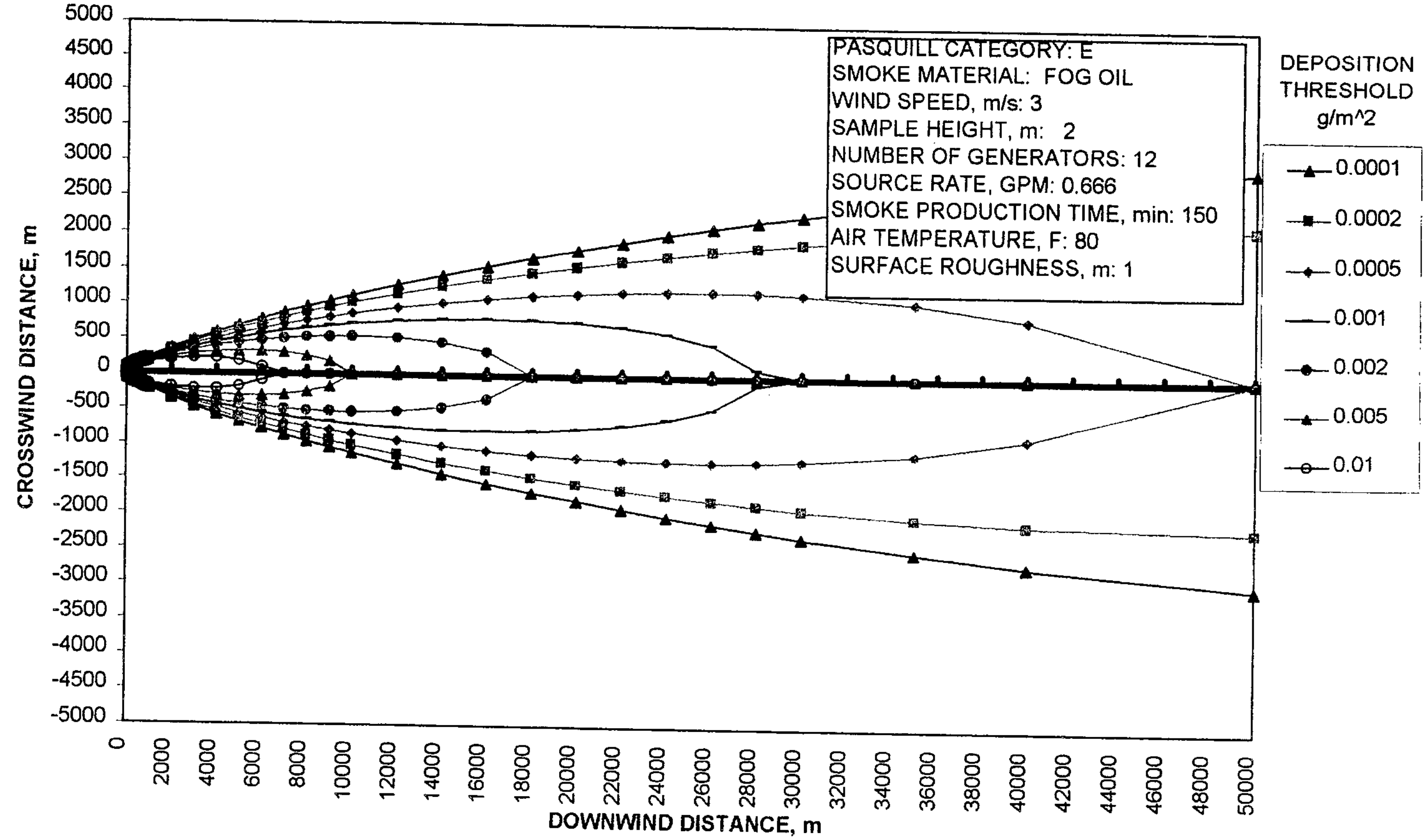


FIGURE 4-12. Deposition of fog oil smoke (Pasquill E) at varying distances from the mobile training areas.

Risk

The risk of acute and chronic effects (at varying distances from the fog oil source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment F. Effects to Indiana bats are expected where the Hazard Quotient (HQ) exceeds 1.0. Effects to Indiana bats are summarized in Table 4-12.

4.5.3.2 Terephthalic Acid

Toxicity

Chemical properties and a general description of terephthalic acid is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of TPA via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.2.6.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. Indiana bats occur nearly installation-wide when they forage or roost during spring staging, during the summer maternity season, and during fall swarming. Indiana bats in hibernacula also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of TPA in air is described in Appendix IV, Section VIII. Figures 4-13 and 4-14 are representative examples of TPA dispersion from grenades and smoke pots in Pasquill atmospheric stability category E. Dispersion of TPA in Pasquill category B is described and plotted in Appendix IV, Section VIII. Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

TABLE 4-12. Summary of toxicological effects anticipated from implementation of the propose
and foraging gray bats are not equivalent to distances between contaminant release sites and hibernacu
wide, "perching" along Roubidoux Creek and Big Piney River, and "nesting" at three sites along the Gas

Proposed Activity			Indiana Bat: Foraging/Roosting	Indiana Bat: In Hibernacula	Foraging
Static fog oil					
	Acute				
		Inhalation			
		Ingestion			
		Dermal absorption			
	Chronic				
		Inhalation	within 4000 m	Davis No. 2 Cave	within 40
		Ingestion			
		Dermal absorption			
Mobile fog oil					
	Acute				
		Inhalation			
		Ingestion			
		Dermal absorption			
	Chronic				
		Inhalation	within 7000 m	Davis No. 2 and Joy caves from Bailey McCann Hollow and Cannon Range (Mush Paddle Hollow) mobile TAs; Wolf Den Cave from Bailey McCann Hollow TA	within 70
		Ingestion			
		Dermal absorption			

ated from implementation of the proposed action. Shading indicates no effects are anticipated. Distances specified for for contaminant release sites and hibernacula or maternity caves. We evaluated the potential for bald eagles to be exposed w nd "nesting" at three sites along the Gasconade River.

Bat	Gray Bat		Bald Eagle		
In Hibernacula	Foraging	In Maternity Caves	Traveling	Perching	
Davis No. 2 Cave	within 4000 m	Saltpeter No. 3			
d Joy caves from Bailey McCann nd Cannon Range (Mush Paddle Hollow) mobile TAs; e from Bailey McCann Hollow TA	within 7000 m	Saltpeter No. 3 Cave Musgrave Hollow, Bailey McCann Hollow and Cannon Range (Mush Paddle Hollow) mobile TAs			

2

g indicates no effects are anticipated. Distances specified for foraging/roosting Indiana bats, aves. We evaluated the potential for bald eagles to be exposed while "traveling " installation-

ıt	Bald Eagle		
⁄laternity Caves	Traveling	Perching	Nesting
Saltpeter No. 3			
. 3 Cave Musgrave Hollow, cCann Hollow and Cannon .ush Paddle Hollow) mobile TAs			

TABLE 4-12. Continued.

Proposed Activity			Indiana Bat		
			Foraging/Roosting	In Hibernacula	Foraging
TPA grenades					
	Acute				
		Inhalation	within 3000 m	Davis No. 2 Cave from Sapper TA Joy Cave from Sapper TA Wolf Den from TA243, TA238, TA238B, R33, and Smoke Training Road Brooks Cave from TA125, TA194	within 3000 r
	Chronic				
		Inhalation	within 3000 m	Davis No. 2 Cave from Sapper TA Joy Cave from Sapper TA Wolf Den from TA243, TA238, TA238B, R33, and Smoke Training Road Brooks Cave from TA125, TA194	within 3000 r

ıdiana Bat	Gray Bat		Bald Ea(		
In Hibernacula	Foraging	In Maternity Caves	Traveling	Perching	
Davis No. 2 Cave from Sapper TA Joy Cave from Sapper TA en from TA243, TA238, TA238B, R33, and Smoke Training Road Brooks Cave from TA125, TA194	within 3000 m	Saltpeter No. 3 Cave from Sapper TA	within 3000 m	Roubidoux Ck. from 240N, 240S, 241, R28, Sapper TA, TA234, and Smoke Training Road Big Piney River from TA126, TA125, and TA194	
Davis No. 2 Cave from Sapper TA Joy Cave from Sapper TA en from TA243, TA238, TA238B, R33, and Smoke Training Road Brooks Cave from TA125, TA194	within 3000 m	Saltpeter No. 3 Cave from Sapper TA			

2

	Bald Eagle		
ernity Caves	Traveling	Perching	Nesting
3 Cave from Sapper TA	within 3000 m	Roubidoux Ck. from 240N, 240S, 241, R28, Sapper TA, TA234, and Smoke Training Road Big Piney River from TA126, TA125, and TA194	
3 Cave from Sapper TA			

TABLE 4-12. Continued.

Proposed Activity			Indiana Bat: Foraging/Roosting	Indiana Bat: In Hibernacula	Foraging
TPA smoke pots					
	Acute				
		Inhalation	within 3000 m	Davis No. 2 and Joy caves from Cannon Range (Mush Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TA Wolf Den Cave from R33	within 300(
	Chronic				
		Inhalation	within 3000 m	Davis No. 2 and Joy caves from Cannon Range (Mush Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TA Wolf Den Cave from R33	within 300(
Titanium dioxide grenades					
	Acute				
		Inhalation			
	Chronic				
		Inhalation			

1

na Bat	Gray Bat		Bald Eagle		
In Hibernacula	Foraging	In Maternity Caves	Traveling	Perching	
and Joy caves from Cannon Range Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TA Wolf Den Cave from R33	within 3000 m	Saltpeter No. 3 Cave from Cannon Range (Mush Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TAs	within 3000 m	Roubidoux Creek from Cannon Range (Mush Paddle Hollow), Bailey/McCann Hollow and Musgrave Hollow Mobile Smoke TAs, and R28	
and Joy caves from Cannon Range Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TA Wolf Den Cave from R33	within 3000 m	Saltpeter No. 3 Cave from Cannon Range (Mush Paddle Hollow) and Bailey/McCann Hollow Mobile Smoke TAs			

2

	Bald Eagle		
nity Caves	Traveling	Perching	Nesting
ave from Cannon Range ow) and Bailey/McCann ollow Mobile Smoke TAs	within 3000 m	Roubidoux Creek from Cannon Range (Mush Paddle Hollow), Bailey/McCann Hollow and Musgrave Hollow Mobile Smoke TAs, and R28	
ave from Cannon Range ow) and Bailey/McCann ollow Mobile Smoke TAs			

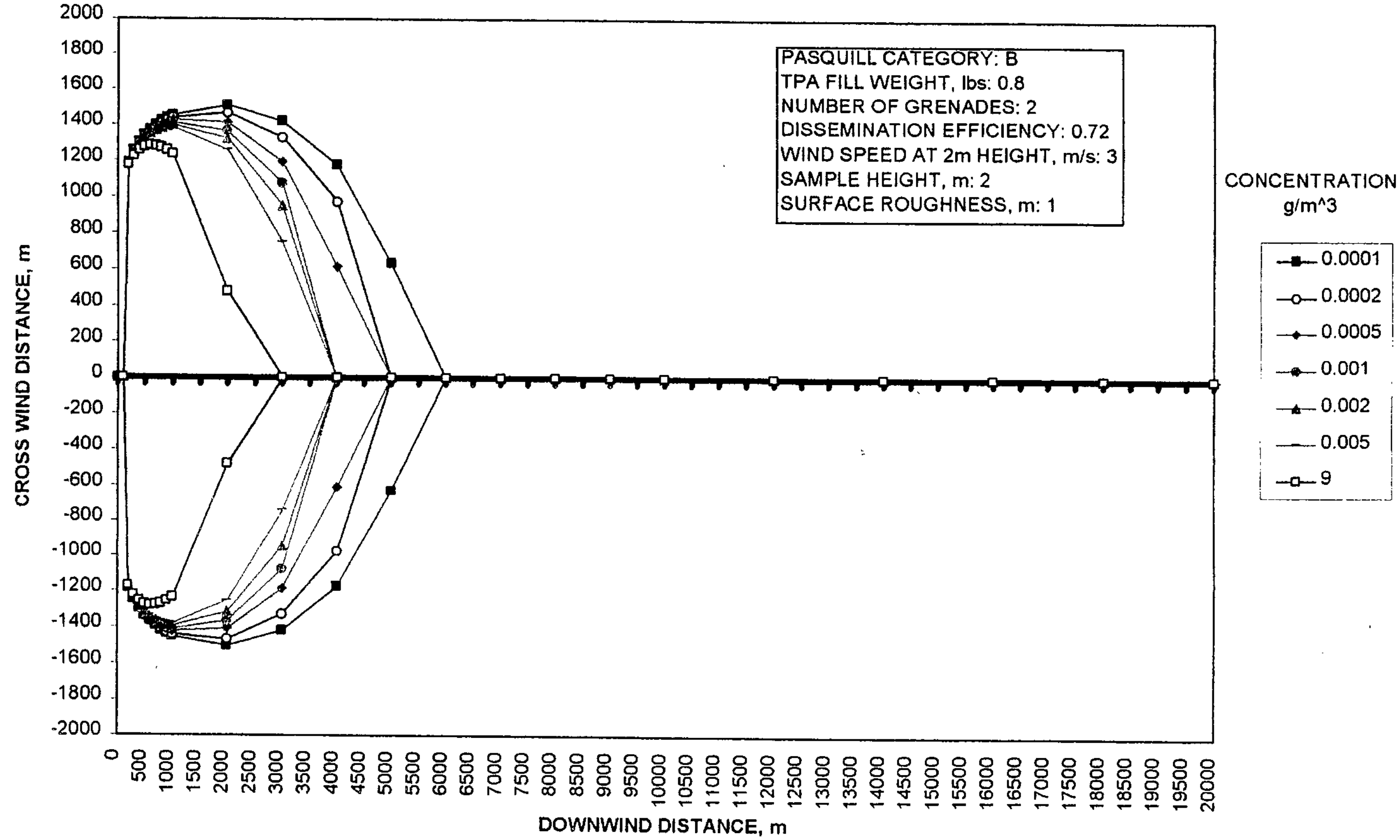


FIGURE 4-13. Concentration of terephthalic acid from smoke grenades (Pasquill B) at varying distances from the source.

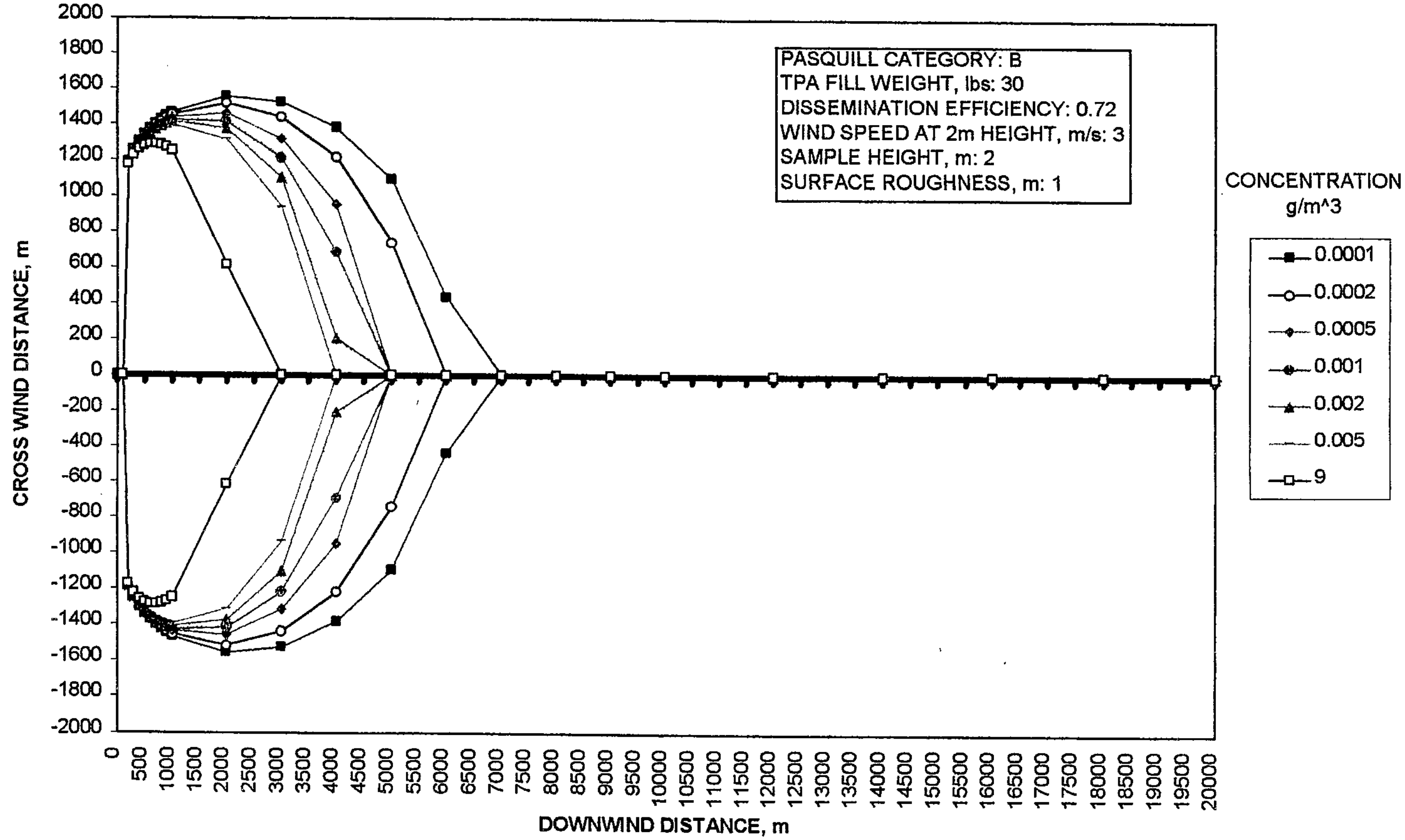


FIGURE 4-14. Concentration of terephthalic acid from smoke pots (Pasquill B) at varying distances from the source.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment C

Risk

The risk of acute and chronic effects (at varying distances from the TPA source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment F. Effects to Indiana bats are expected where HQs exceed 1.0. Effects of proposed TPA training on Indiana bats are summarized in Table 4-12.

4.5.3.3 Titanium Dioxide

Toxicity

Chemical properties and a general description of titanium dioxide is provided in Appendix IV, Section V. Section 7.5 of Appendix IV describes the toxicity of titanium dioxide via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of titanium dioxide are discussed in Appendix IV, Section 7.5.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when Indiana bats forage or roost during spring staging, during the summer maternity season, and during fall swarming. Indiana bats in hibernacula also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of titanium dioxide in air in Pasquill category E is described in Appendix IV, Section VIII (Figure 4-15). Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

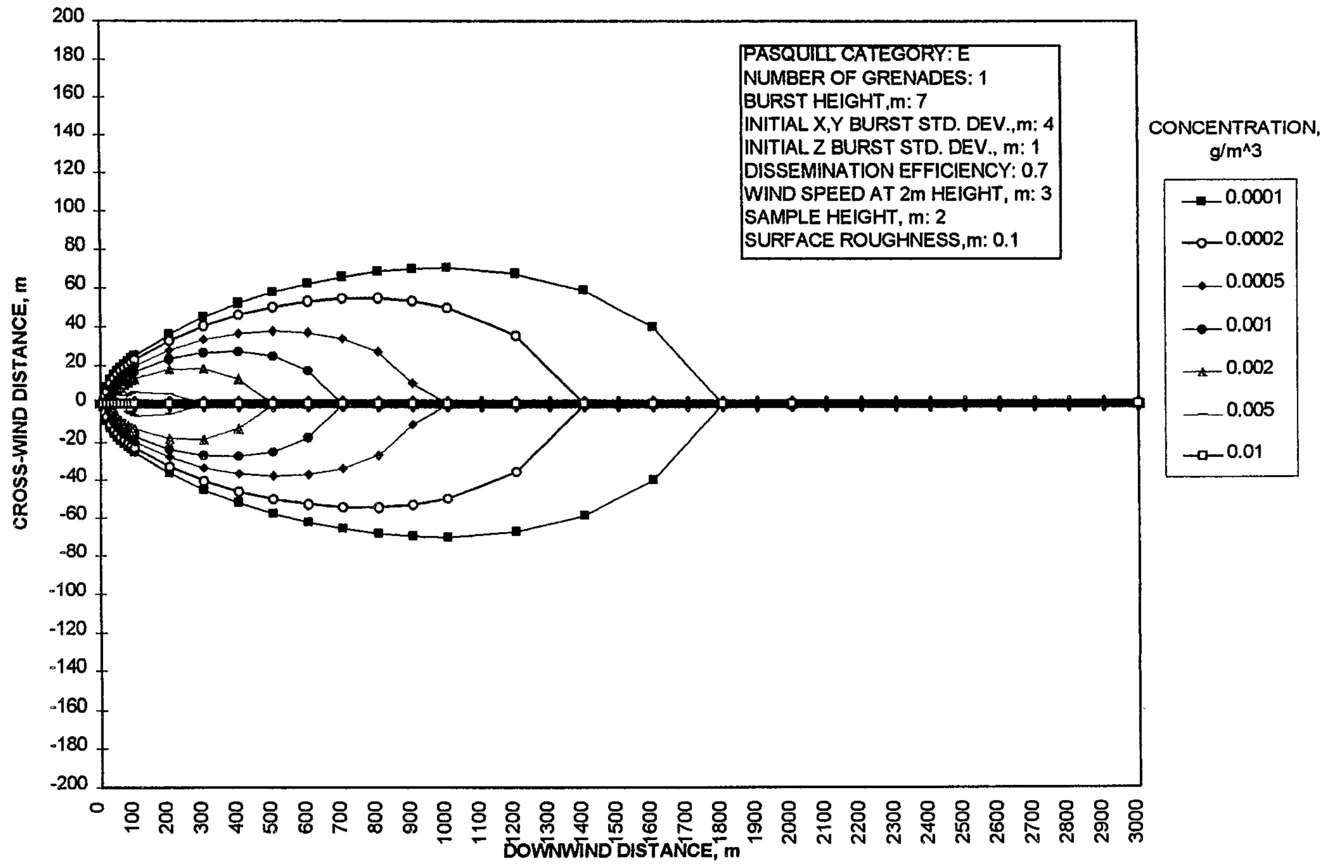


FIGURE 4-15. Concentration of titanium dioxide from grenades (Pasquill E) at varying distances from the source.

Intake

Calculations of acute (single exposure event) and chronic (exposure over lifetime of receptor) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment C.

Risk

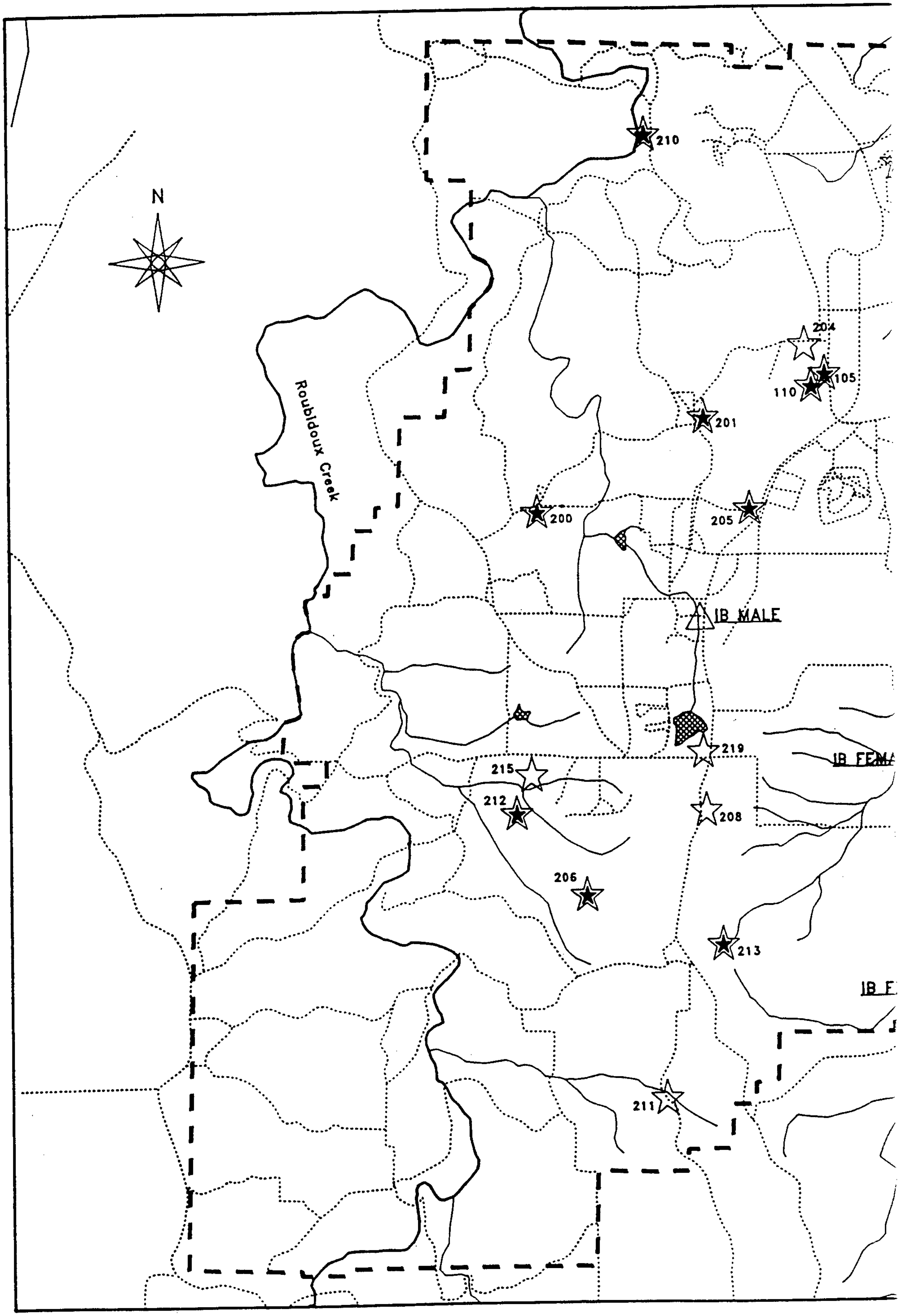
The risk of acute and chronic effects (at varying distances from the titanium dioxide source in Pasquill category E) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment F. Effects to Indiana bats are expected where HQs exceed 1.0. Effects to Indiana bats are summarized in Table 4-12.

4.6 EFFECTS ANALYSIS/DISCUSSION

4.6.1 Effect of BRAC-Related Construction to Indiana Bat Summer Habitat

During the summer of 1994, 3D/Environmental conducted extensive mist net surveys (52 sites) throughout the Installation for the *Biological Assessment of the Master Plan and Ongoing Mission for the US Army Engineer Center and Fort Leonard Wood* (3D/Environmental 1996a). Two reproductive females and one male were captured, documenting use of the Installation by Indiana bats during summer (Figure 4-1). Although this species appears to be present in small numbers during summer, removal of suitable summer habitat may affect Indiana bats using the area.

Proposed construction at Fort Leonard Wood will remove approximately 178 acres of forested habitat. There will be a loss of 48.74 Habitat Units (the equivalent of 48.74 acres of optimal Indiana bat summer habitat). Seventeen construction sites contribute to the loss of suitable forested habitat (Figure 4-16). Construction activity may kill or injure individuals if they are roosting in trees when the trees are cut or otherwise cleared. Forest clearing also may degrade foraging habitat.



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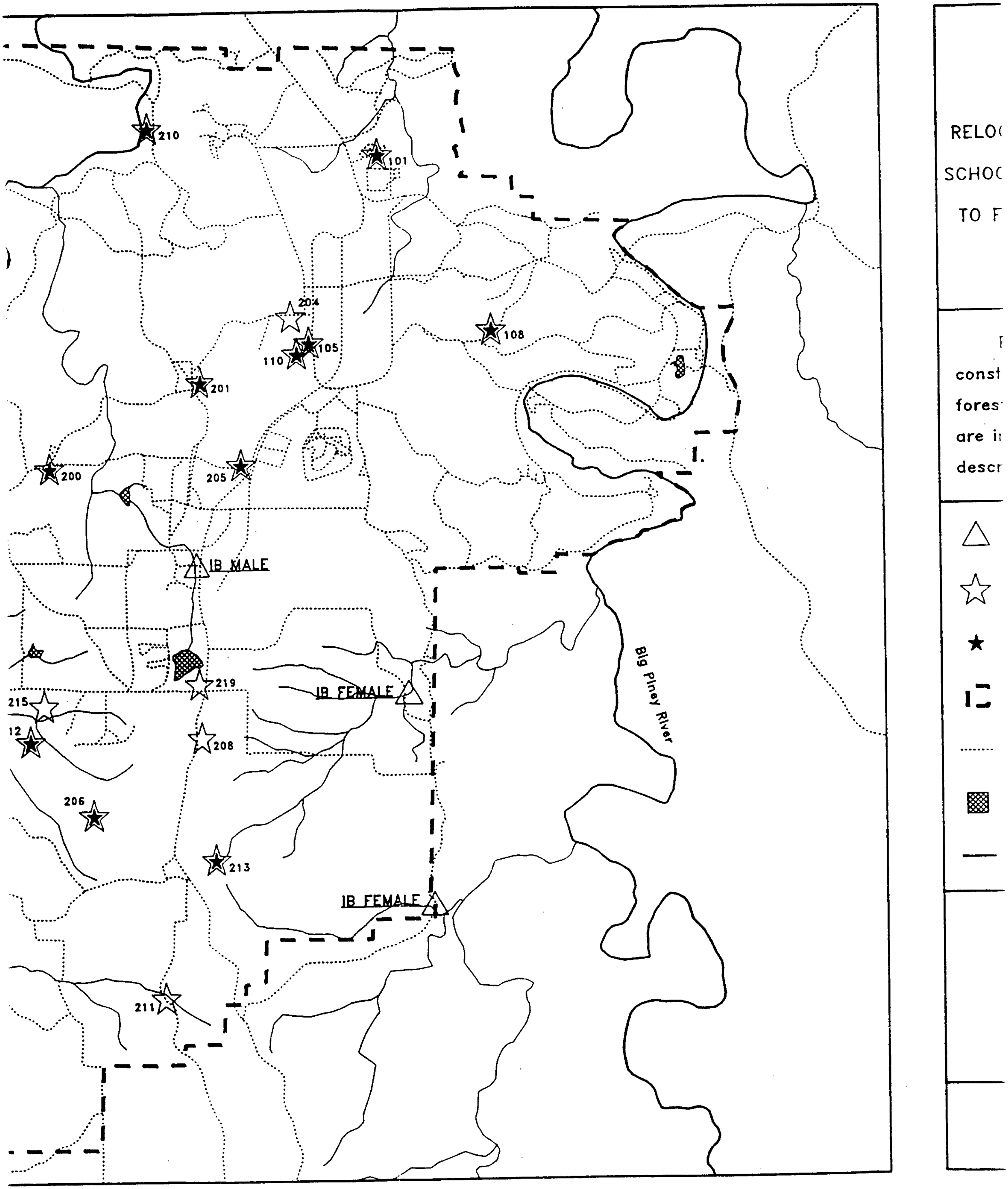
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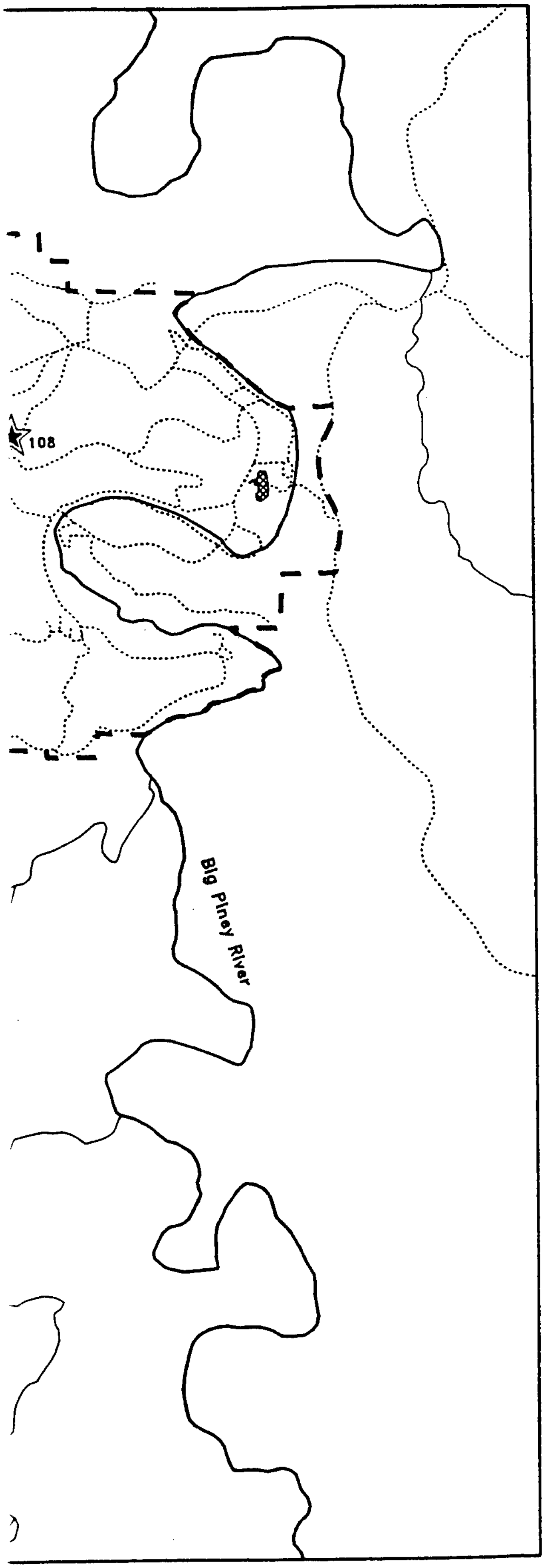


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 4–16. Support facility construction sites requiring removal of forest. Three Indiana bat capture sites are indicated. Numbers refer to project descriptions in Table 4–7.

△ Indiana Bat Mist Net Capture Site

☆ New Support Facilities With Forest Removal

★ New Support Facilities With Suitable Roost Tree Removal

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers
0 2 4

3D/ENVIRONMENTAL

(3)

4.6.1.1 Roost Habitat

Proposed construction may directly affect Indiana bats roosting in trees felled during construction. Indiana bats roost in trees during several seasons of the year at Fort Leonard Wood (Table 4-13).

Removing suitable roost trees could affect Indiana bats in two ways: 1) if bats are roosting in a tree when it is cut, mortality could occur; and 2) energy used to find new roost sites may stress the bats. Female Indiana bats tend to return to the same maternity areas and in some cases the same tree annually (Gardner et al. 1991a). Because some maternity roost trees remain suitable for only a few years, Indiana bats may have to find different summer nursery roosts several times during a decade. By the time most Indiana bats arrive at their new summer areas, they may have limited fat reserves. Searching for a new roost tree or maternity area will cause a bat to expend additional energy. This effort could be especially costly to a pregnant female.

Construction activities at 12 sites will remove trees containing suitable roosting sites for maternity colonies and/or solitary individuals. Female Indiana bats form maternity colonies under exfoliating bark or in hollows of trees. Maternity colonies generally require large, high quality, suitable roost trees to accommodate many individuals. Over 100 individuals have been documented in Indiana bat maternity roosts (J. Whitaker, pers. comm.). Males generally are solitary and do not require roost trees with as much suitable roosting space. Trees over 22 cm dbh with >25% exfoliating bark provide high quality habitat for maternity roost sites; individual bats may roost in trees as small as 8 cm in diameter (3/D Environmental 1996b). The highest risk

TABLE 4-13. Seasons in which Indiana bats roost in trees.

Season	Approximate Dates	Use
Spring	early March - late May	staging (females and males)
Summer	April 15 - September 15	maternity colonies (females and young), males roost in trees
Autumn	August 15 - early November	swarming (females and males)

of direct injury or mortality of summer Indiana bats is associated with removal of high quality suitable roost trees. Approximately 226 trees to be removed during construction have characteristics of high quality suitable roost sites. The number of high quality suitable roost trees currently existing on Fort Leonard Wood is estimated at 72,386 (1.7 per acre X 42,580 acres of forest).

Construction activities are unlikely to affect summer roosts used by Indiana bats captured on the Installation during 1994 because capture sites are not close to construction areas and the size of habitat disturbance areas is small. All construction sites requiring removal of suitable roost trees are at least 3.5 km from sites where female Indiana bats were captured. Removal of suitable roost trees will not occur within 3.0 km of the site where the male bat was captured (Figure 4-16).

Gardner et al. (1991a) reported the mean distance traveled between a maternity roost and foraging areas for pregnant and lactating females was 1.054 km (n=5) and 1.035 km (n=12), respectively. Males are typically solitary during summer and travel a mean distance of 0.557 km (n=9) from roosts to foraging areas (Gardner et al. 1991a). Although construction sites requiring tree removal will occur well outside the mean travel distances, these sites are within known maximum travel distances for Indiana bats. 3D/Environmental (1995) found the maximum distance Indiana bats traveled from a roost (presumably during foraging) was 4.7 km for adult females (n=3) and 3.7 km for an adult male. Indiana bats utilizing habitat where other Indiana bats were captured in 1994 may utilize roost habitat within the construction areas. Construction sites comprise a small percentage of suitable roosting habitat available within the maximum travel distances of the capture sites.

Almost any trees over approximately 8 cm dbh, with exfoliating bark, may provide roost habitat Indiana bats during spring staging and fall swarming, and for male bats during the summer (3D/Environmental 1996b). Any activities removing trees greater than or equal to this size may directly affect Indiana bats roosting in the trees.

4.6.1.2 Foraging Habitat

Construction will reduce availability of forest currently suitable for foraging; however, the amount to be removed is minimal compared to the amount of forest on the Installation. The 178

acres of forest to be removed is 0.42% of the approximate 42,580 acres of forest on Fort Leonard Wood.

The tracts of forest to be cleared are small (mean = 4.3 ac) compared to the amount of forest habitat available near construction sites, and the amount of habitat required for foraging. Proposed construction sites requiring tree removal have a mean of 52% forest cover within a 1 km radius. Optimal habitat contains $\geq$ 30% forest cover within 1 km (Rommé et al. 1995).

Foraging ranges of Indiana bats are large. Gardner et al. (1991b) reported mean foraging range sizes for pregnant females, lactating females, and adult males to be 133 ac, 234 ac, and 128 ac respectively. If Indiana bats use proposed construction areas for foraging, only a small portion of the suitable habitat within their foraging range will be removed. It is unlikely proposed construction will reduce forest cover enough to substantially affect the quality of foraging habitat within the Installation, or within 1 km of construction sites.

Fort Leonard Wood will beneficially affect the quality of Indiana bat habitat with development and implementation of management strategies described in Section 2.2.2 of this Biological Assessment. Policy and management guidance to be developed by this project design feature will seek to maintain or enhance the quality of Indiana bat roosting and foraging habitat Installation-wide.

4.6.2 Effect of BRAC-Related Sound on Hibernating Indiana Bats

Results of experimental presentations of recorded training activities to hibernating little brown bats indicate sounds generated by BRAC-related training do not cause bats to arouse from hibernation. When data from 3 replicates were pooled, we found no significant treatment effects. Data do not support rejecting the null hypothesis; presentations did not generate a number of responses significantly different than expected. These results concur with our evaluation of sound generated by ongoing mission activities (3D/Environmental 1996a)

Sound pressure levels of stimuli in this study were predicted by modeling, and presented at 65 to 115 dB (1 to 10 dB above background; see Tables 5 and 6 in Appendix I to the Ongoing Mission Biological Assessment for a detailed listed of background sound levels). In our previous study (3D/Environmental 1996a), we did not observe arousal responses to stimuli presented as high as 126 dB (approximately 60 dB above background levels). In a supplemental study, we

presented the same ongoing mission stimuli to 28 hibernating little brown bats (3D/Environmental 1996a). Again, no response was observed to stimuli presented at 65 to 115 dB (1 to 50 dB above background). These results suggest sound stimuli alone are unlikely to disturb hibernating bats.

Arousals were periodically observed (Tables 4-10 and 4-11) during the 4- and 8-hour post stimulus periods. Our data do not indicate more arousals occurred during these periods than expected. Because there is individual variability in periods of hibernation, there is always a chance of several arousals during a 4- or 8-hour period. In replicate 2, control bats (n = 6) exhibited a period of hibernation lasting an average of 3.33 days while that for experimental bats (n = 10) was 3.13 days (± s.d. 2.25 days and 2.96 days, respectively). In the 3 days prior to presentation of the construction stimulus, no bats in the experimental group had aroused. Therefore, arousals were observed during the post-stimulus periods because the bats were near the end of an average hibernation period.

In replicate 3, control bats (n = 6) exhibited a period of hibernation lasting an average of 4.2 days while the experimental group (n = 10) averaged 3.88 days (± s.d. 4.1 days and 2.58 days, respectively). Only one arousal in the experimental group was observed in the 4 days prior to presentation of the Range 4 (Night Infiltration Training) stimulus. Again, bats were near the end of an average hibernation period at the time the stimulus was given.

Video monitoring did not indicate stimuli disturbed hibernating bats. We looked for startle responses or other movements which could indicate stimuli were detected and posed a potential disturbance to bats. Tactile stimuli, such as blowing on a roosting bat, will cause the bat to withdraw, open its mouth, and sometimes vocalize. Similar immediate responses can be observed when hibernating bats are illuminated by an intense light source. The fact that no movements were observed immediately following stimulus presentations is another indication observed arousals may not have been in response to stimuli.

Arousals observed following the presentation of construction and night infiltration stimuli in replicates 2 and 3 were most likely because the post-stimulus periods fell within the end of a hibernation period. Pooled data analyses show these effects are likely artifacts and that sound stimuli tested do not disturb hibernating little brown bats. Because little brown bats are serving as a surrogate species for Indiana bats, we apply these results and conclude that sounds tested will not disturb hibernating Indiana bats.

4.6.3 Effect of Toxicological Agents

A number of proposed training activities may expose Indiana bats to unsafe concentrations of stressors. We assessed the potential for acute and chronic effects. The discussion below focuses upon effects summarized in Table 4-12 and described in greater detail in Appendix IV. In the following sections, we estimate the number of bats to be affected where we predict effects. Estimates of the number of bats to be affected are based upon the following assumptions:

- We estimate one Indiana bat maternity colony occurs on or near Fort Leonard Wood. The largest documented maternity colonies contain approximately 100 individuals. We assume the maximum summer population on or near the Installation is 100.
- Where unsafe exposure concentrations reach hibernacula, we assume all bats in the cave will be affected. We base estimates of the number of bats in the caves on surveys of hibernating populations completed in 1995 and 1996.
- We assume all Indiana bats hibernating in caves on Fort Leonard Wood also stage and swarm at their respective hibernacula. For purposes of estimating the potential maximum number of Indiana bats affected, we assume all foraging and roosting during these periods occurs outside caves. We assume Indiana bats occur during staging and swarming wherever there is suitable habitat on the Installation.
- We assume foraging Indiana bats may occur installation-wide.

4.6.3.1 Static Fog Oil Training

Acute Effects

Foraging and roosting bats may occur nearly installation-wide. Indiana bats forage and roost outside caves during the summer maternity period, and during staging and swarming. Under conditions we assessed, a single exposure to fog oil generated during static training will not affect foraging or roosting Indiana bats through ingestion, inhalation, or dermal absorption. Indiana bats in hibernacula on Fort Leonard Wood, and those in Great Spirit Cave will not be exposed to unsafe concentrations.

Chronic Effects

Indiana bats foraging or roosting within 4000 m of the static smoke training area may inhale unsafe concentrations of fog oil resulting in chronic effects. A substantial mist netting effort in 1994 yielded only 3 Indiana bats on the Installation during the maternity season.

Assuming 1994 capture results indicate the presence of one Indiana bat maternity colonies on or near the Installation, we *conservatively* estimate chronic inhalation effects described above could affect approximately 100 individual bats during the maternity season.

Indiana bats hibernating in Davis No. 2 Cave may inhale concentrations of fog oil resulting in chronic effects. Numbers of bats exposed while swarming, staging, or hibernating can be conservatively estimated by assessing the 1996 censuses of Davis No. 2 Cave (Table 4-1). The count documented 34 Indiana bats hibernating in Davis No. 2 Cave.

4.6.3.2 Mobile Fog Oil Training

Acute Effects

A single exposure to fog oil generated during mobile training will not affect foraging, roosting, or hibernating Indiana bats through ingestion, inhalation, or dermal absorption.

Chronic Effects

Under conditions we assessed, Indiana bats may be affected through inhaling unsafe concentrations of fog oil. Indiana bats foraging/roosting within 7000 m of mobile smoke training areas may inhale unsafe concentrations of fog oil resulting in chronic effects. An estimated 100 Indiana bats may be present on the Installation during the maternity season, and be exposed to these chronic effects.

Indiana bats repeatedly hibernating in Davis No. 2 or Joy caves may inhale unsafe concentrations of fog oil generated on Bailey/McCann, and Cannon Range (Mush Paddle Hollow) mobile smoke TAs. A 1996 census of Davis No. 2 and Joy caves documented a total 53 Indiana bats hibernating in the two caves (Table 4-1).

Indiana bats hibernating in Wolf Den Cave may inhale unsafe concentrations of fog oil generated on Bailey/McCann mobile smoke training area. The 1996 census documented 3 Indiana bats hibernating in the Wolf Den Cave (Table 4-1).

4.6.3.3 Terephthalic Acid Grenades

Acute Effects

Under conditions we assessed, a single exposure to TPA will affect foraging and roosting Indiana bats within 3000 m of the source. We conservatively estimate acute inhalation effects could affect less than 100 individual bats during the maternity season. Each bat could be affected more than once.

Hibernating Indiana bats in the 4 hibernacula on Fort Leonard Wood may inhale unsafe concentrations of TPA released at certain TPA training sites (Table 4-12). *Acute* effects will be realized through inhalation only. Numbers of bats exposed while swarming, staging, or hibernating can be conservatively estimated by assessing the most recent censuses of Brooks, Davis No. 2, Wolf Den, and Joy caves. Counts completed in these hibernacula in 1996 documented approximately 592 Indiana bats.

Chronic Effects

Repeated exposure to TPA smoke from grenades will chronically affect foraging/roosting, and hibernating Indiana bats via inhalation. Effects to foraging/roosting and hibernating Indiana bats are identical to acute effects described above.

The assessment of chronic effects evaluated worst-case exposure in that we assumed individual bats would be exposed to TPA each time it is released, regardless of wind direction. We assumed all releases would occur during the portion of the year when bats are present on the installation. However, TPA grenades will also be used when bats are absent from the installation, therefore the number of exposures may be lower than the number we assessed. For example, we assessed effects of exposure to 3136 TPA grenades. If actual exposures result from 105 or fewer grenades, there will be no chronic effects.

4.6.3.4 Terephthalic Acid Smoke Pots

Acute Effects

The effects of smoke pots are similar to those of TPA grenades. Smoke pots are deployed at fewer locations (9) than TPA grenades (22). Under conditions we assessed, a single

exposure to TPA will affect foraging and roosting Indiana bats within 3000 m of the source. We conservatively estimate acute inhalation effects could impact less than 100 individual Indiana bats during the maternity season. Each bat could be affected more than once.

Hibernating Indiana bats in 3 hibernacula on Fort Leonard Wood may inhale unsafe concentrations of TPA released at certain TPA training sites (Table 4-12). *Acute* effects will be realized through inhalation only. Numbers of bats exposed while swarming, staging, or hibernating can be conservatively estimated by assessing the most recent censuses of Davis No. 2, Wolf Den, and Joy caves. Counts completed in these hibernacula in 1996 documented approximately 56 Indiana bats.

Chronic Effects

Repeated exposure to TPA smoke from grenades will chronically affect Indiana bats via inhalation. Effects to foraging/roosting and hibernating Indiana bats are similar to acute effects described above.

The assessment of chronic effects evaluated worst-case exposure in that we assumed individual bats would be exposed to TPA each time smoke pots are released, regardless of wind direction. We assumed all releases would occur when bats are present on the installation. However, TPA smoke pots will also be used during portions of the year when bats are absent from the installation, therefore the number of exposures may be lower than the number we assessed. For example, we assessed effects of exposure to 950 TPA smoke pots. If actual exposures result from 107 or fewer smoke pots (foraging/roosting Indiana bats), or 79 smoke pots (hibernating Indiana bats), there will be no chronic effects.

4.6.3.5 Titanium Dioxide Grenades

Acute Effects

No acute effects are expected.

Chronic Effects

No chronic effects are expected.

4.6.4 Cumulative Effects

Effects of the proposed action are described in this biological assessment. Effects of the ongoing mission at Fort Leonard Wood are described in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a).

Future federal activities in the action area not analyzed in this Biological Assessment, or the Biological Assessment of the Ongoing Mission, require specific assessment for Endangered Species Act compliance. No non-federal action affecting Indiana bats are reasonably certain to occur within the action area. No cumulative effects are anticipated.

4.7 STATEMENT OF FINDING

4.7.1 Effect of BRAC-Related Construction to Indiana Bat Summer Habitat

Proposed construction activities may affect Indiana bats in summer maternity colonies, and Indiana bats in tree roosts during staging and swarming; and during the summer.

Proposed activities may affect habitat utilized by foraging Indiana bats.

Proposed development of forest management guidelines will beneficially affect summer habitat of the Indiana bat.

4.7.2 Effect of BRAC-Related Sound on Hibernating Indiana Bats

Sound generated by BRAC activity will not affect hibernating Indiana bats in Brooks, Wolf Den, Davis No. 2, and Joy caves on Fort Leonard Wood.

4.7.3 Effect of Toxicological Agents

Under the conditions we assessed, fog oil, TPA grenades, and TPA smoke pots may affect Indiana bats. If conditions vary from those we used to model dispersion of fog oil and TPA, it is likely expected effects may decrease.

Section 5
Gray Bat (*Myotis grisescens*)

Section 5:

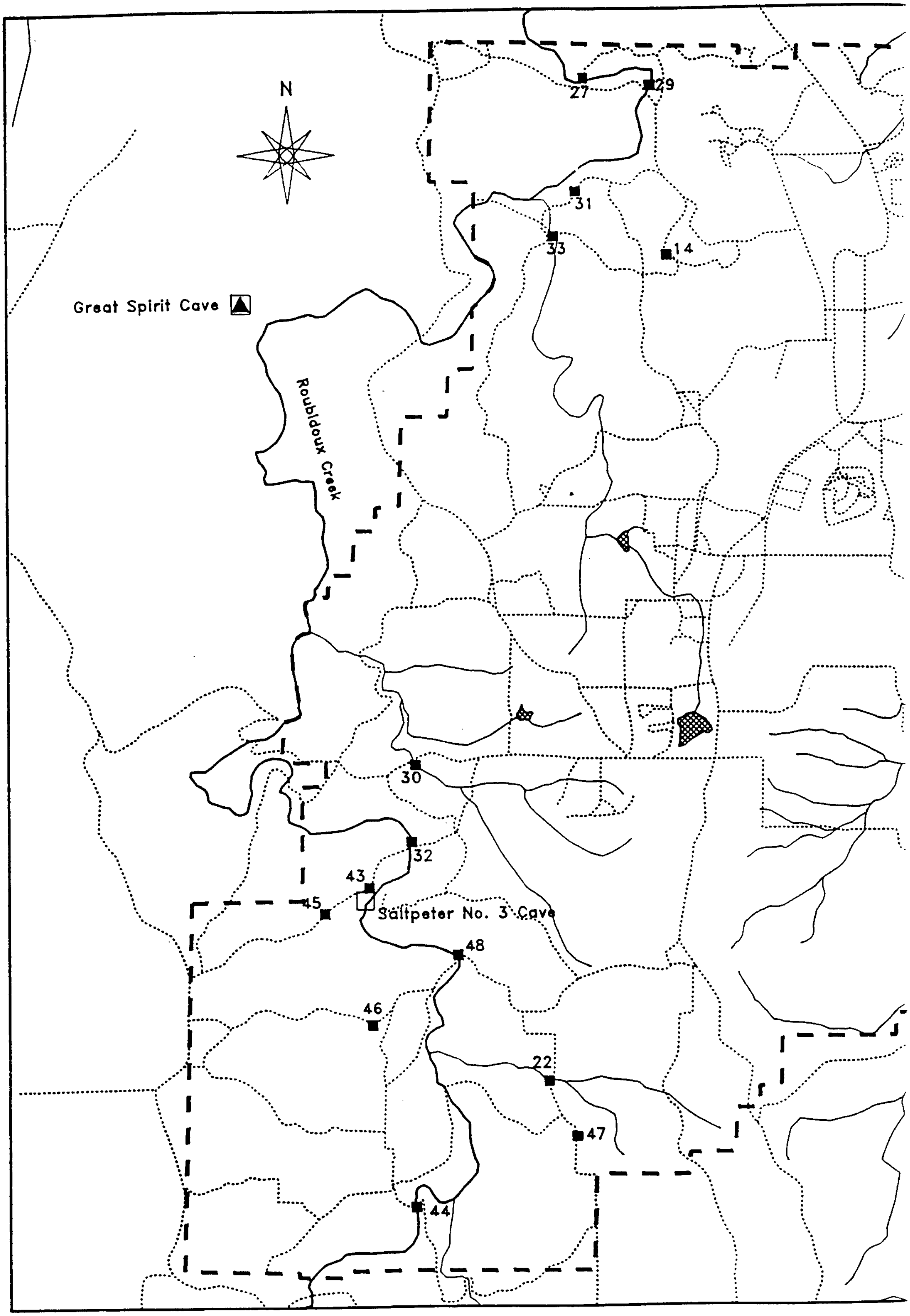
Gray Bat
(Myotis grisescens)

5.1 BACKGROUND

3D/Environmental provides a detailed description of the species in the Biological Assessment of the Master Plan and Ongoing Mission (1996). Section 5 of that document describes the species' legal status, life history, and geographic range. We incorporate those narratives by reference to limit redundancy.

5.1.1 Gray Bats on Fort Leonard Wood

Gray bats occur throughout most of the southern half of Missouri, except for extreme southeastern counties. Fort Leonard Wood, predominantly in Pulaski County, is near the center of the species range in Missouri, and also near the center of counties occupied by the "central subpopulation" in the state. Most gray bats in the central subpopulation hibernate in Coffin Cave in Laclede County. This subpopulation is the largest of the three in Missouri in number of bats, number of maternity caves, and geographic area (Missouri Department of Conservation 1992). Gray bat numbers within the subpopulation were characterized in 1992 as "stable to increasing" (Missouri Department of Conservation 1992). No critical habitat (as defined in Section 4 of the Endangered Species Act) has been designated. A gray bat maternity colony inhabits Saltpeter No. 3 Cave (Figure 5-1). Although gray bats may use Davis No. 2 Cave, the season and magnitude of use has not been documented. Great Spirit Cave, 2.2 miles (3.5 km) west of Fort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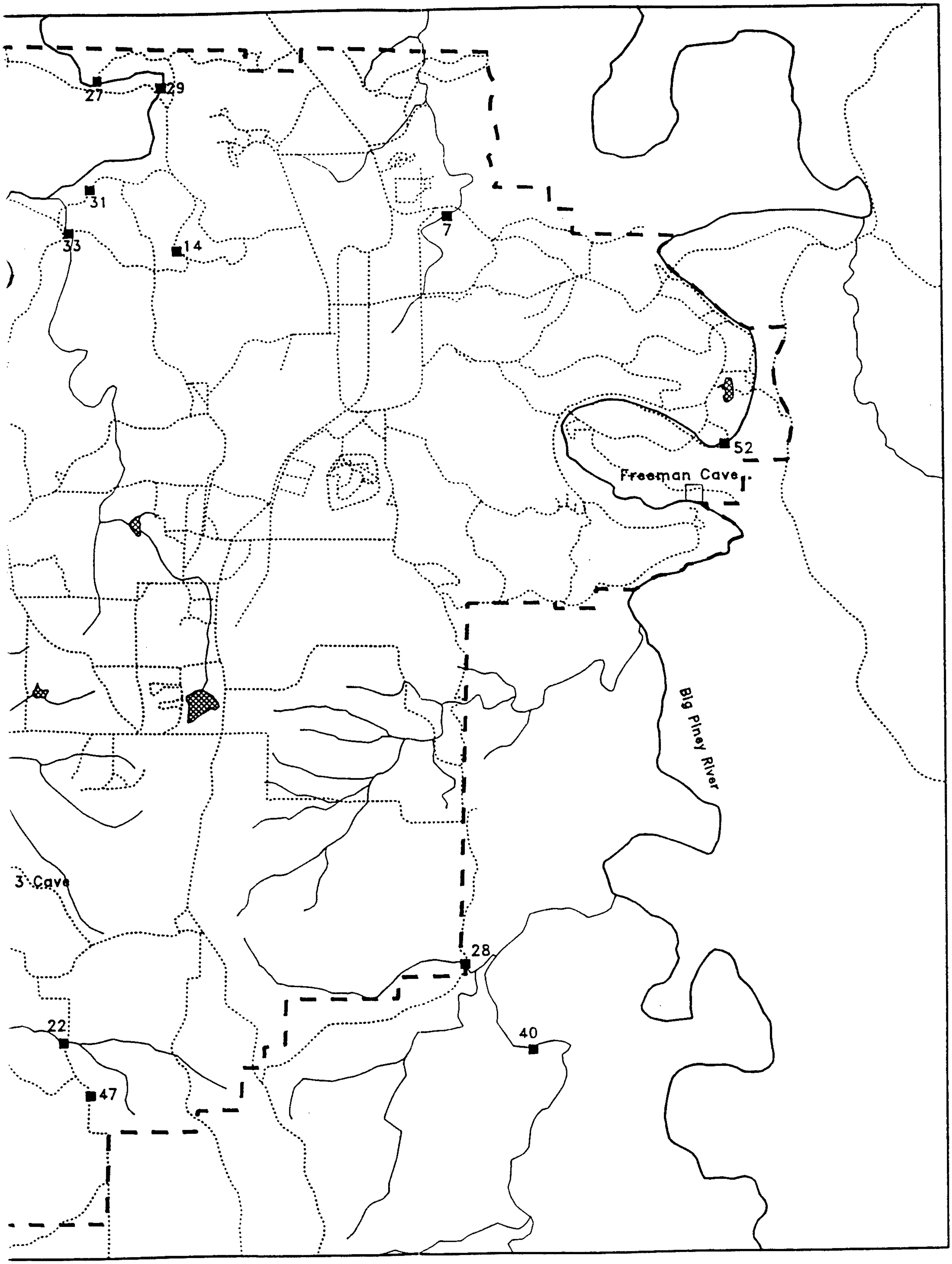

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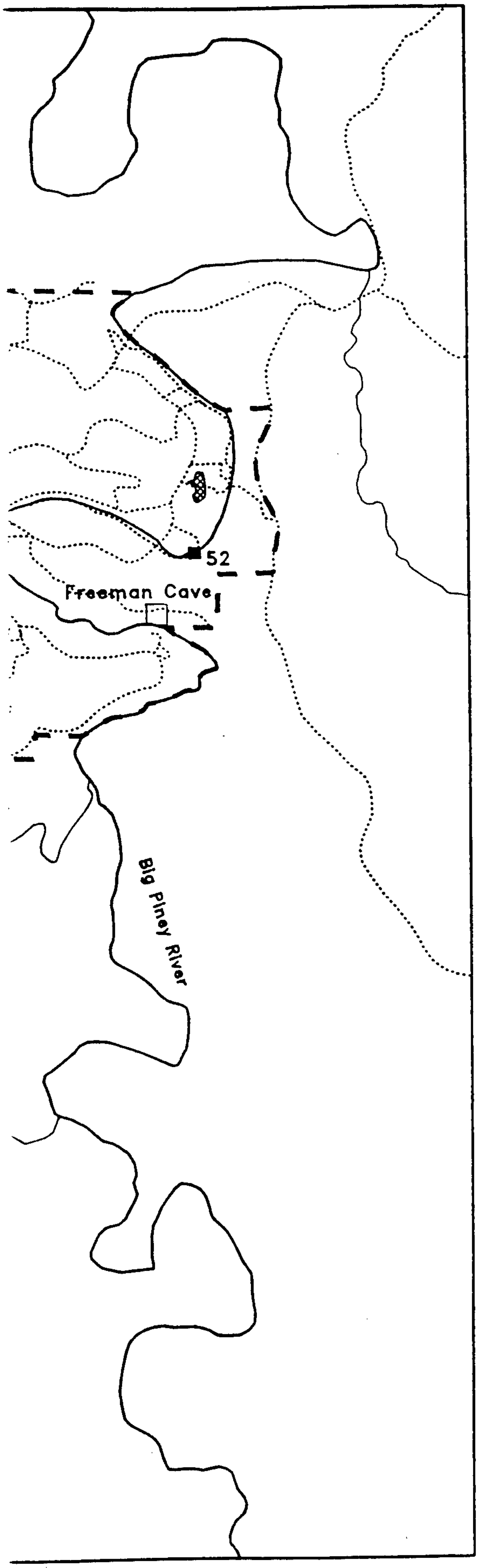
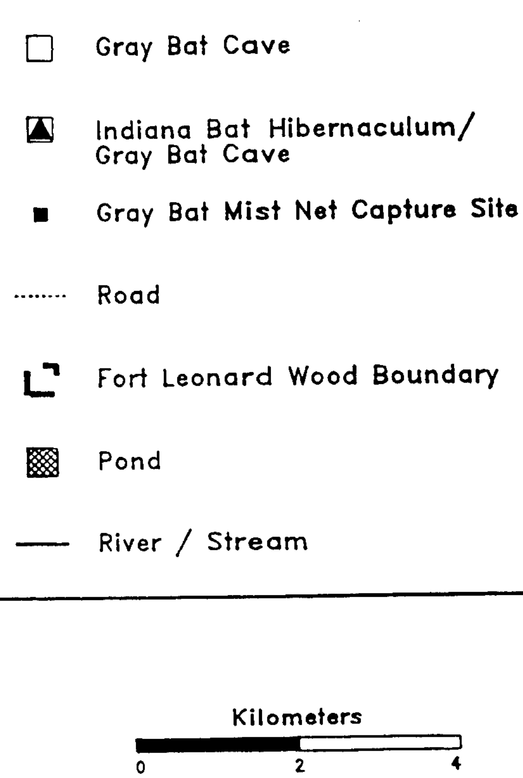


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 5-1. Gray bat caves and gray bat capture sites on or near Fort Leonard Wood, Missouri.



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Leonard Wood, also supports a maternity colony (Missouri Department of Conservation 1994, Missouri Department of Conservation 1992) (Table 5-1). Gray bats are not known to hibernate on the installation.

Gray bats have been observed in Freeman Cave in the past. Oesch and Oesch (1986) reported the "chimney" of Freeman Cave was used by an "undetermined" species of bat as evidenced by stains left on the rocks and the thick pad of guano. The Missouri Department of Conservation (1994) reported an estimated population of 3740 gray bats based on guano accumulations in Freeman Cave. The Missouri Department of Conservation (1994) estimated a maximum past population of 1000, based on guano accumulations. 3D/Environmental harp-trapped the entrance to Freeman Cave on May 22, 1994 and captured 2 adult male, and 2 pregnant female gray bats (3D/Environmental 1996a).

3D/Environmental mapped Freeman Cave for this BA. The "chimney" described by Oesch and Oesch (1986) is a dome approximately 40 feet high. We have observed gray bats roosting in this dome. Guano accumulates below this roost; however, gray bat guano falls from the roost area to a sloped ledge before falling to the cave floor. Because the number of gray bats estimated by MDC (1994) was based on the area of guano, this number may be an underestimate.

TABLE 5-1. Gray bat populations in caves on and near Fort Leonard Wood, Missouri (Nov 24, 1993 Missouri Natural Heritage Database, Missouri Department of Conservation 1994, Rick Clawson, pers. comm., FWS 1982).

Year	Great Spirit (Inca) Cave	Freeman Cave	Saltpeter No. 3 Cave
1964	3000		
1977		0	
1978	4000		
1980	10,000		
1986			3000-5000
1987	25,800		
1989	0		
1990	10,200		
1992	20,400		
1994	12,250	3740	3740

To determine the seasonal use of Freeman Cave by gray bats, 3D/Environmental surveyed the cave in January, May, July, and September, 1996. No gray bats were found hibernating in Freeman Cave in January. One hundred thirty seven gray bats (94F : 43M) were captured at Freeman Cave on May 15-16. Fourteen females were pregnant. During daylight hours on July 8-9, 1996, no gray bats were present in Freeman Cave. Adult and juvenile gray bats were captured (six on July 8, and eight on July 9) coming into the cave later each evening (8F : 2M : 4 juv). Only one gray bat captured in May or July was recaptured on another night. Gray bats (62F : 39 M) were captured at the entrance to Freeman cave on September 23-24. Two of the bats had been captured previously, one on July 8, 1996 (at Freeman Cave) and one on August 11, 1994 at mist net site 52 (Figure 5-1). Our data documents gray bats using Freeman Cave in all seasons except winter.

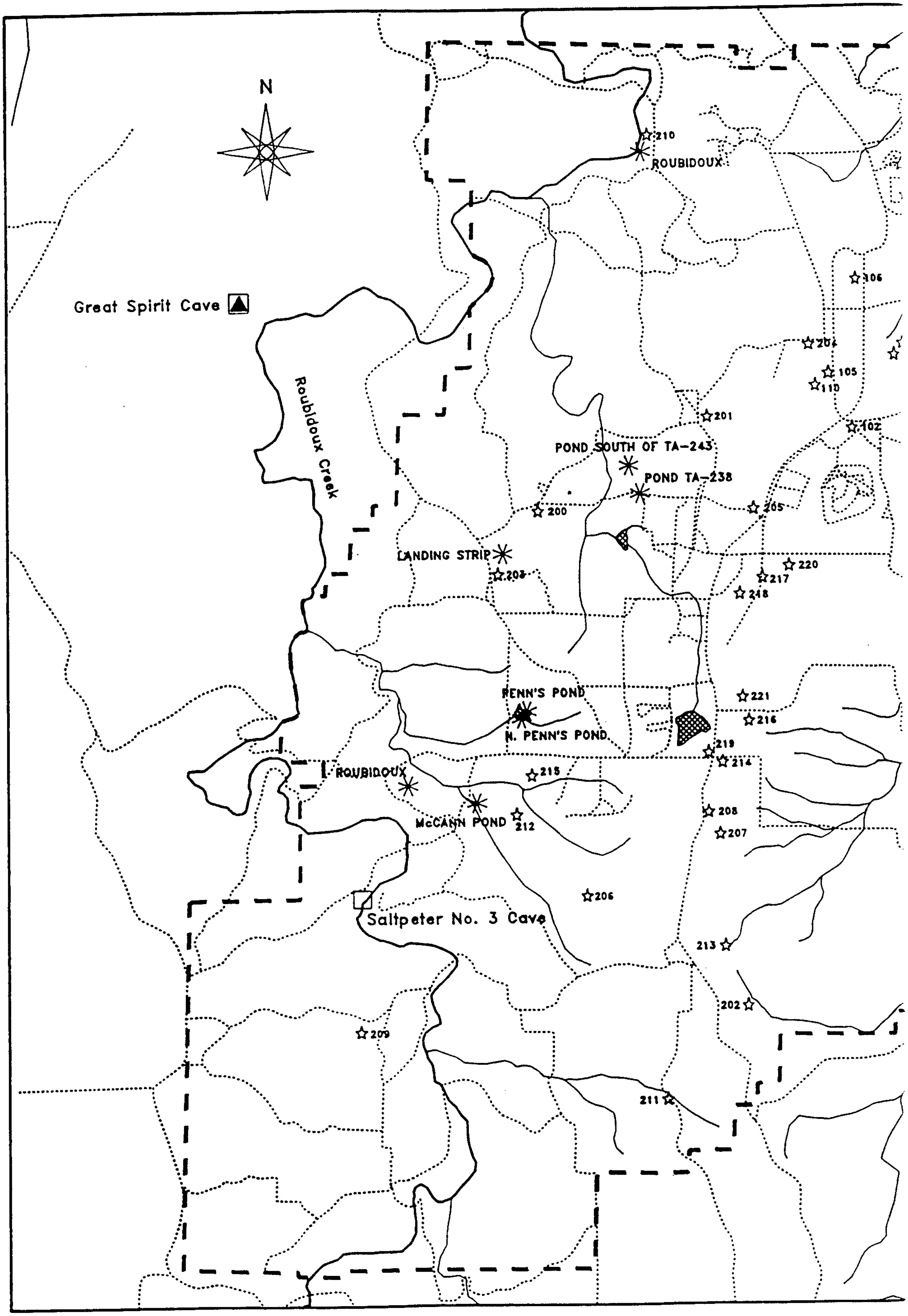
To minimize disturbance to gray bats in Freeman Cave, we timed the July survey near the average time when young gray bats become volant. There is a risk of missing maternity behavior at this time because gray bat colonies may be very mobile. Timing of volancy varies with cave climate. Freeman Cave's structure creates a warm air trap which may provide high quality maternity habitat. Gray bats could have used Freeman Cave as a maternity site between May 15 and July 8, and moved to another cave before our July 8 survey.

5.1.2 Scope of Analysis

This biological assessment focuses upon aspects of the proposed action with reasonable potential to affect gray bats. We assess 3 general categories of effects described in Sections 5.1.2.1 through 5.1.2.3 below.

5.1.2.1 Effect of Habitat Modification Caused by Proposed Construction

The proposed action includes construction and modification of buildings, training ranges and other support facilities (Figure 5-2). We assessed effects to summer habitat of gray bats on the Installation. We addressed the potential for, and magnitude of, impacts to forested habitat near gray bat maternity caves, between maternity caves and nearby riparian areas, within 30 m of streams where gray bats have been captured on the Installation, within 30 m of streams with suitable flight/foraging corridors, and within 30 m of surface water impoundments. We focused our analysis upon areas within 30 meters of waterways because it is within this area that the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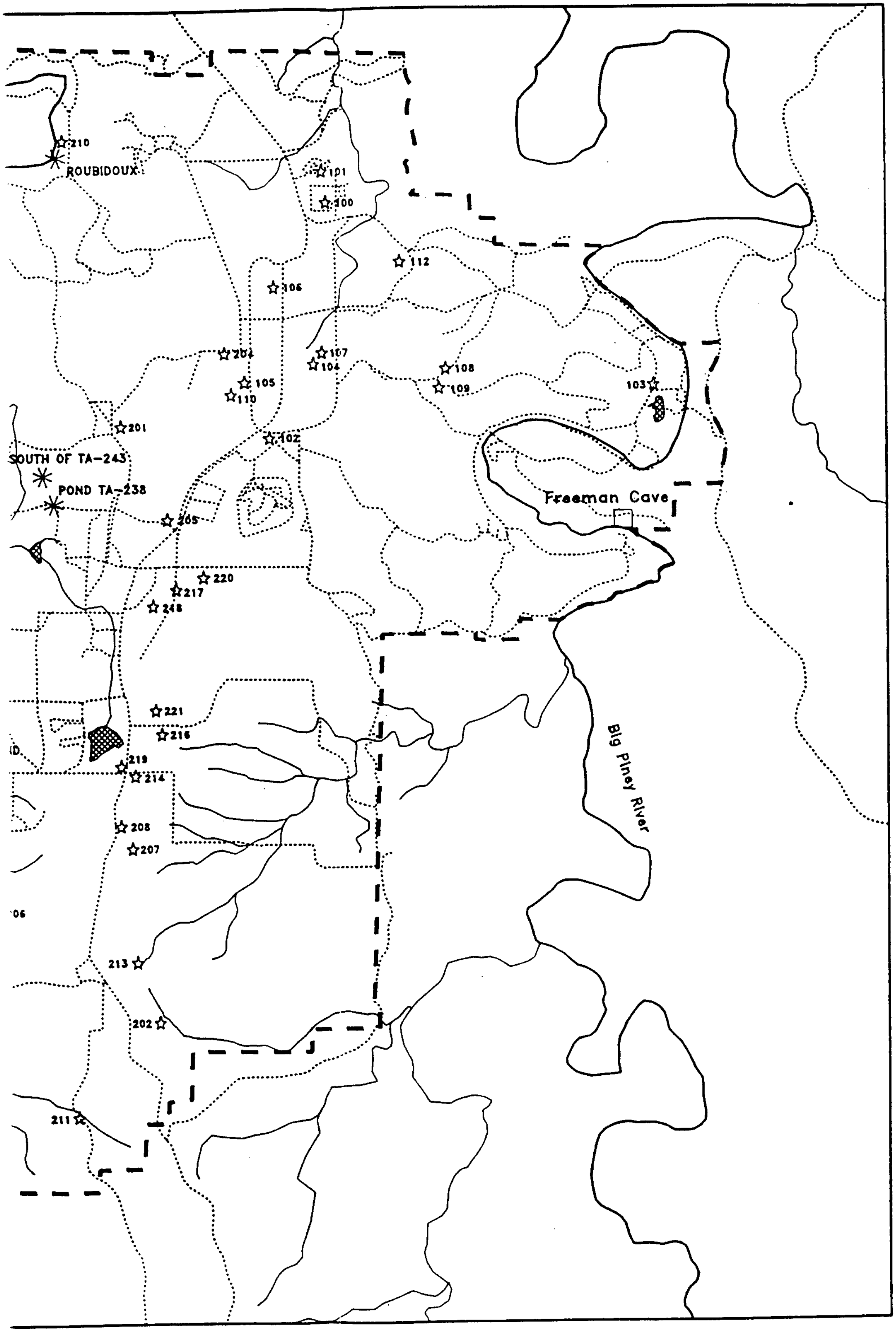

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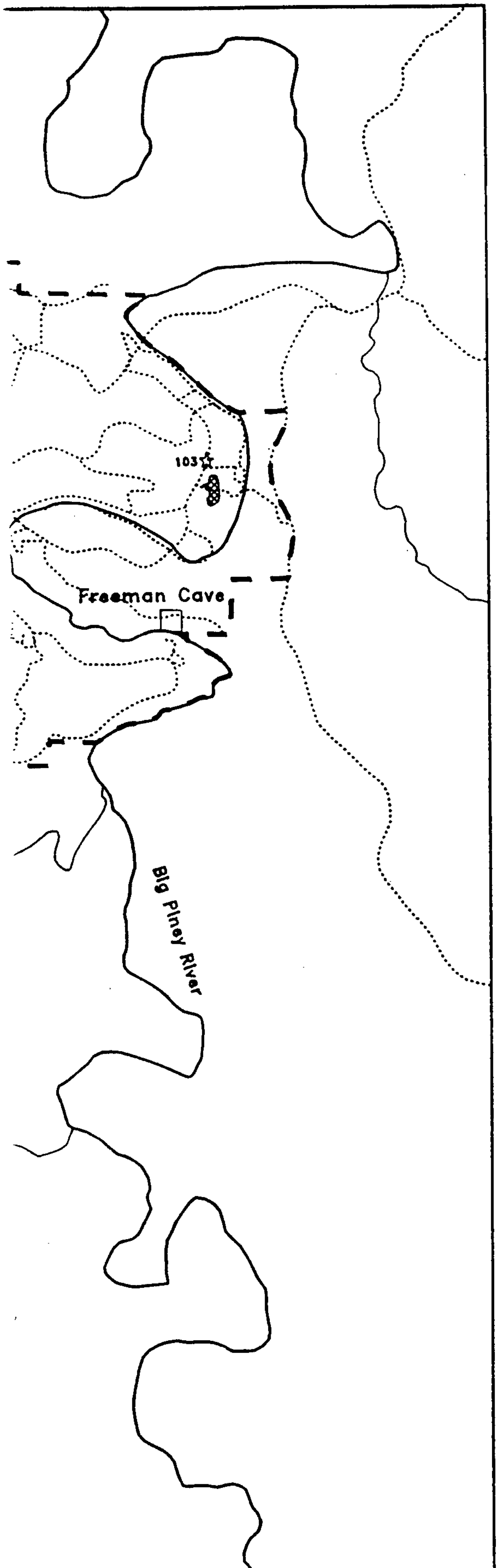

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FIGURE 5-2. Proposed locations of new facilities and BRAC training, and gray bat caves on Fort Leonard Wood, Missouri. Numbers refer to project descriptions in Table 4-7.

- Gray Bat Cave
- Indiana Bat Hibernaculum/ Gray Bat Cave
- New Support Facility
- Potential Decontamination Site
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream

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Missouri Department of Conservation recommends application of riparian forest management guidelines to protect gray bat foraging habitat (MDC 1992).

5.1.2.2 Effect of BRAC-Related Sound on Non-Hibernating Gray Bats

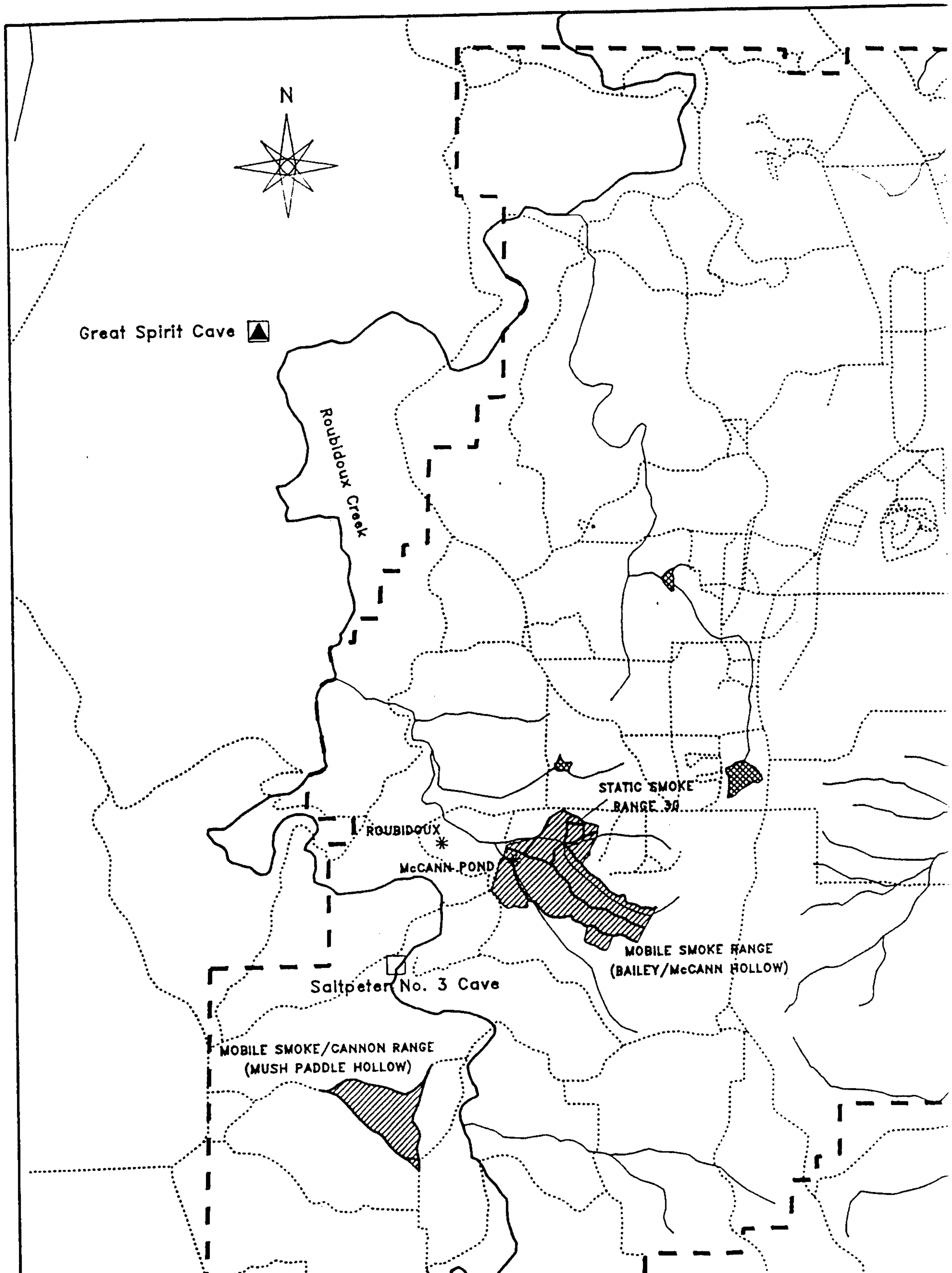
Gray bats in Saltpeter No. 3 and Davis No. 2 caves have potential to be impacted by sound generated by training on mobile smoke training areas (Cannon Range and Bailey/McCann Hollow locations). The proposed mobile smoke training areas on Cannon Range is 1750 m from Saltpeter No. 3 Cave; the Bailey/McCann location is 2420 m from Davis No. 2 Cave (Figure 5-3). We examined sound sources from other training activities and determined none had potential to affect non-hibernating gray bats roosting in Saltpeter No. 3, Davis No. 2, or Freeman caves.

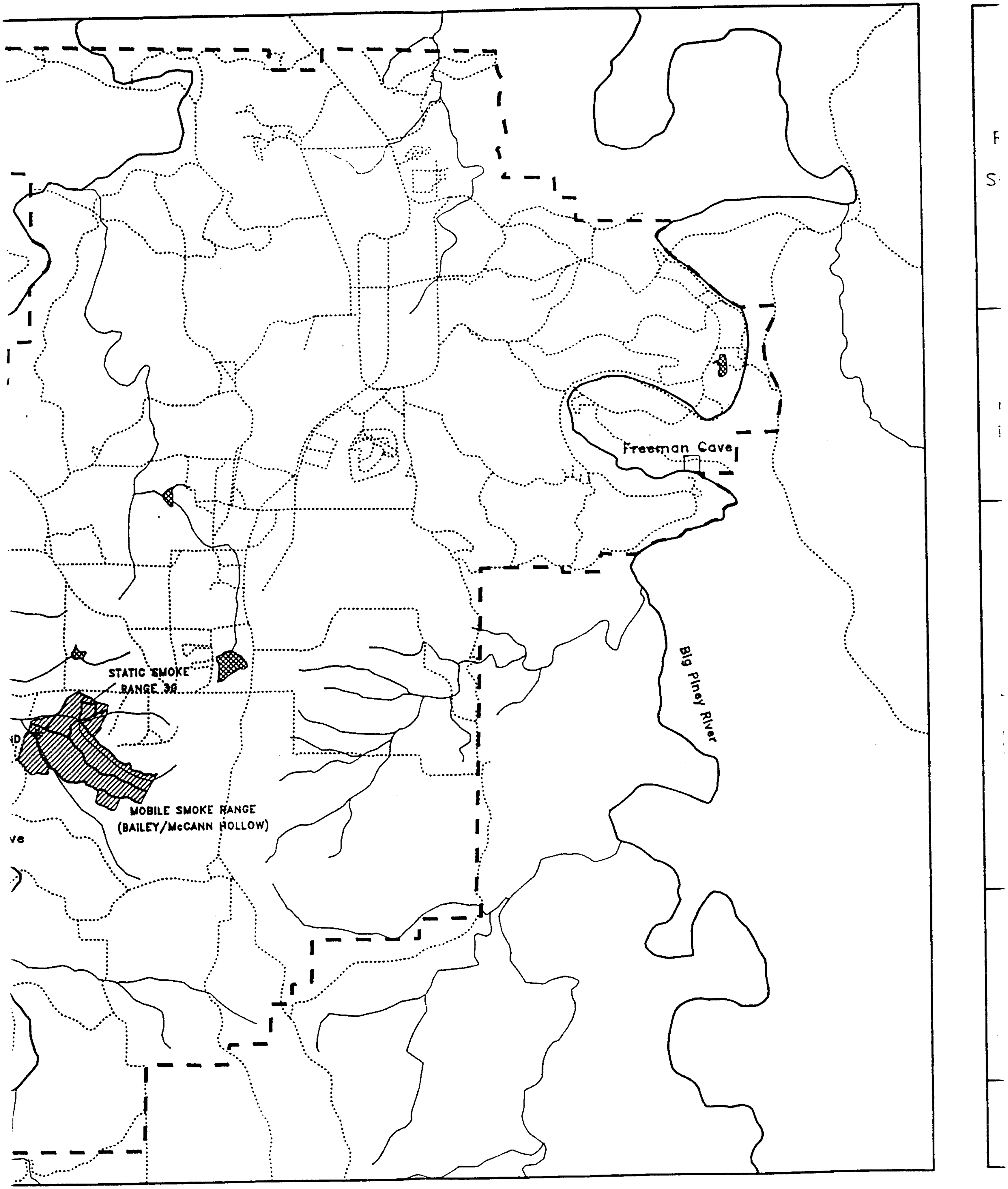
Vehicle mounted "smoke generators" produce obscurant fogs on mobile smoke training areas. FLW (Emily Brown, January 9, 1996) recommended examination of two configurations of smoke generators for this study, the M56 and M157, both mounted on high mobility multipurpose wheeled vehicles (HMMWVs). The M56 uses a turbine engine to vaporize fog oil to produce obscurants. The M157 uses a pulse jet engine to vaporize fog oil to produce an obscurant fog.

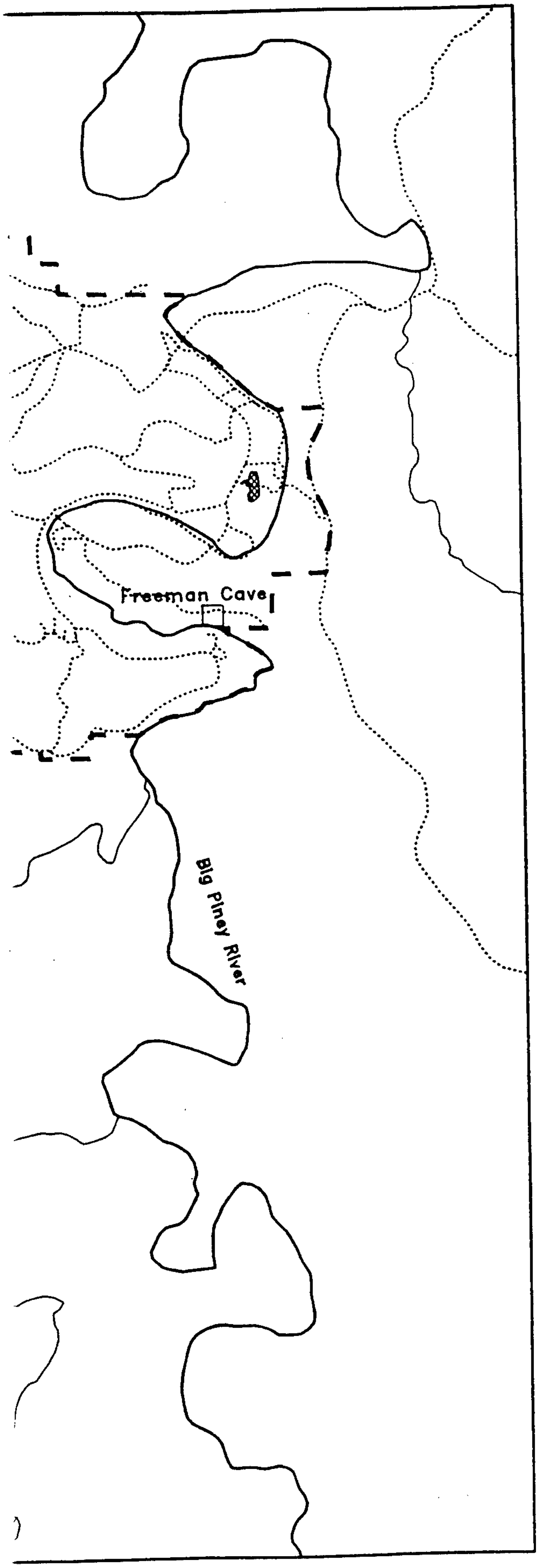
5.1.2.3 Effect of Toxicological Agents

Gray bats may be exposed to training substances when they roost in maternity caves or forage on the Installation from approximately April 1 through October 31. Gray bats use Saltpeter No. 3 and Freeman caves during the maternity season. We used recent survey information to assess the magnitude of effects to gray bats in Saltpeter No. 3, Freeman, and Great Spirit caves during the maternity season. Available information does not facilitate characterization of the recent use, if any, of Davis No. 2 Cave. 3D/Environmental assessed the potential for toxicological effects from exposure to a variety of training materials (Appendix IV, Attachment A).

- Certain materials were excluded from detailed analysis in a preliminary screening. Exclusion was based upon an assessment of toxicity, quantity to be used, storage and use location, and method of deployment (Appendix IV, Attachment A).
- Certain training materials were assumed to be of limited threat to listed species, and were not evaluated. Potential effects of these substances will be assessed in a biomonitoring plan to be implemented by the Installation (see Section 2.2.4 of this BA).


N
Great Spirit Cave
Roubidoux Creek
STATIC SMOKE
RANGE 30
ROUBIDOUX
McCANN POND
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
Saltpeter No. 3 Cave
MOBILE SMOKE/CANNON RANGE
(MUSH PADDLE HOLLOW)


STATIC SMOKE
RANGE 30
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
Freeman Cave
Big Piney River



BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 5–3. BRAC–related training ranges generating sound potentially impacting gray bats in caves.

□ Gray Bat Cave
Indiana Bat Hibernaculum/ Gray Bat Cave
* Potential Decontamination Site
Mobile Smoke Training Area
— Mobile Smoke Deployment Road
Fort Leonard Wood Boundary
...... Road
Pond
— River / Stream

Kilometers
0 2 4

3D/ENVIRONMENTAL

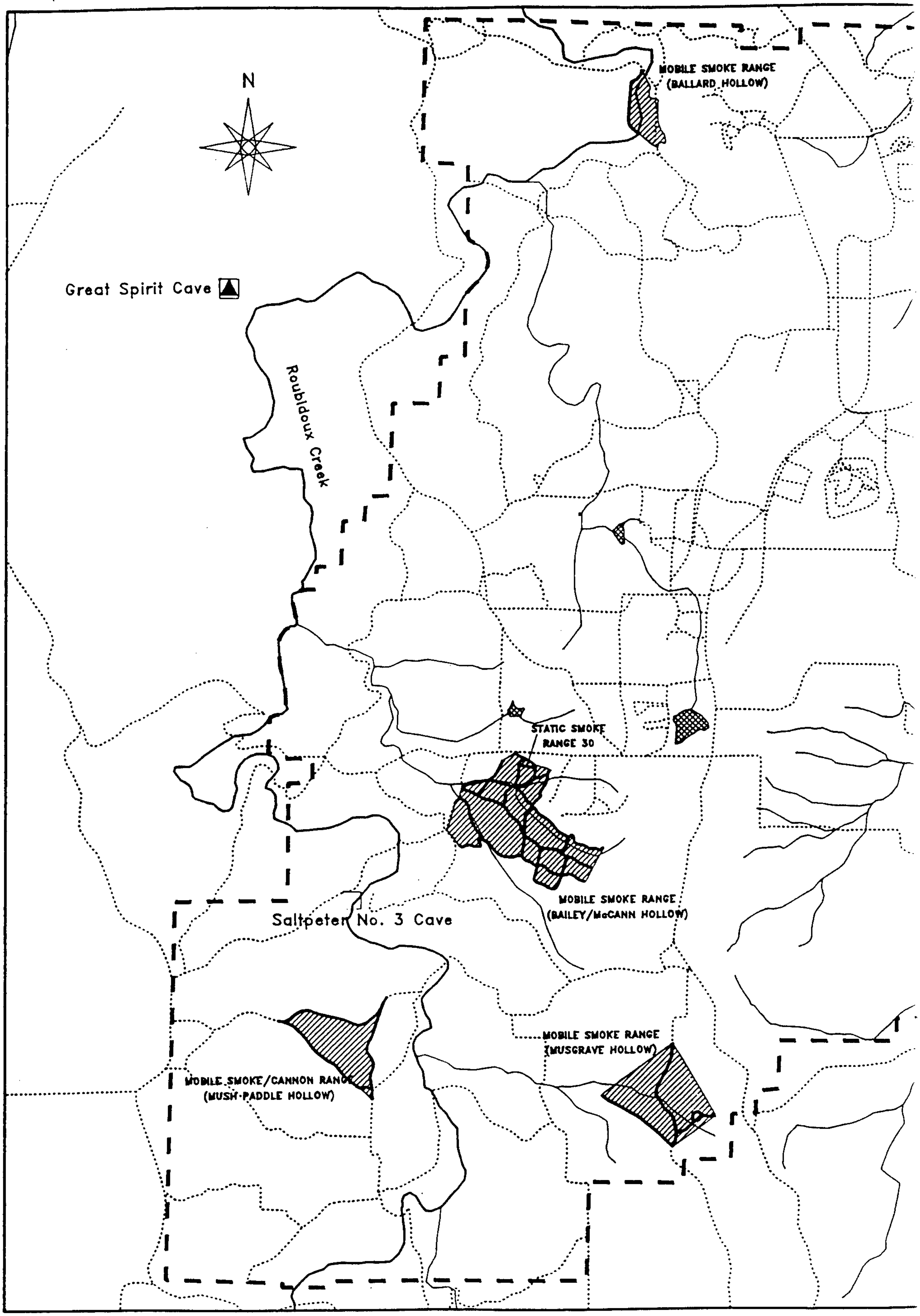
- Certain materials were excluded from detailed analysis based upon results of a screening level risk assessment (Appendix IV, Attachment A).
- Remaining training materials were evaluated in detail in an Ecological Risk Assessment (Appendix IV). We evaluated effects of fog oil obscurant (Figure 5-4), terephthalic acid grenades and smoke pots (Figure 5-5), and titanium dioxide grenades (Figure 5-5).

We considered exposure to toxic concentrations of any stressor to be an effect. Maximum concentrations at which stressors are nontoxic were converted to toxicological values or doses (e.g. NOAEL = No Observable Adverse Effects Level) not expected to result in adverse health effects. Because toxicity data were derived from studies of laboratory animals (e.g. rats), uncertainty factors (UF) were applied when deriving toxicity values for receptors. Uncertainty factors account for anatomical, physiological, or morphological differences between species for which the dose was calculated and the species of concern.

Toxicity Reference Values (TRV) were developed by applying uncertainty factors (UF) to the doses (TRV = NOAEL/Uncertainty Factors) following Department of Army guidelines (Wentsel et al. 1994) and procedures outlined in Calabrese and Baldwin (1993). TRVs provide conservative estimates for toxicological effects levels where species-specific toxicity data are lacking. For example, most gray bat TRVs in this BA were derived by reducing toxicity values of other mammals by a factor of 1600 (1600 is the product of several multiplicative uncertainty factors). The TRV approach is similar to the RfD approach used in human health risk assessments. Most RfDs developed for humans are derived from non-human toxicity values reduced by uncertainty factors ranging from 10 to 10,000.

For fog oil, BIDS simulants, FOX Training simulants, and non-specific simulants, we determined acute and chronic toxicity values available in the literature. We calculated acute and chronic toxicity of TPA using BATS.XLS. 3D/Environmental (1996a) describe the BATS.XLS model.

Toxicological effects exhibited by test species from which TRVs were derived may or may not adequately characterize effects likely to be manifested in receptors we evaluate here.



N
MOBILE SMOKE RANGE
(BALLARD HOLLOW)
Great Spirit Cave
Roubidoux Creek
STATIC SMOKE
RANGE 30
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
Saltpeter No. 3 Cave
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)
MOBILE SMOKE/CANNON RANGE
(MUSH-PADDLE HOLLOW)

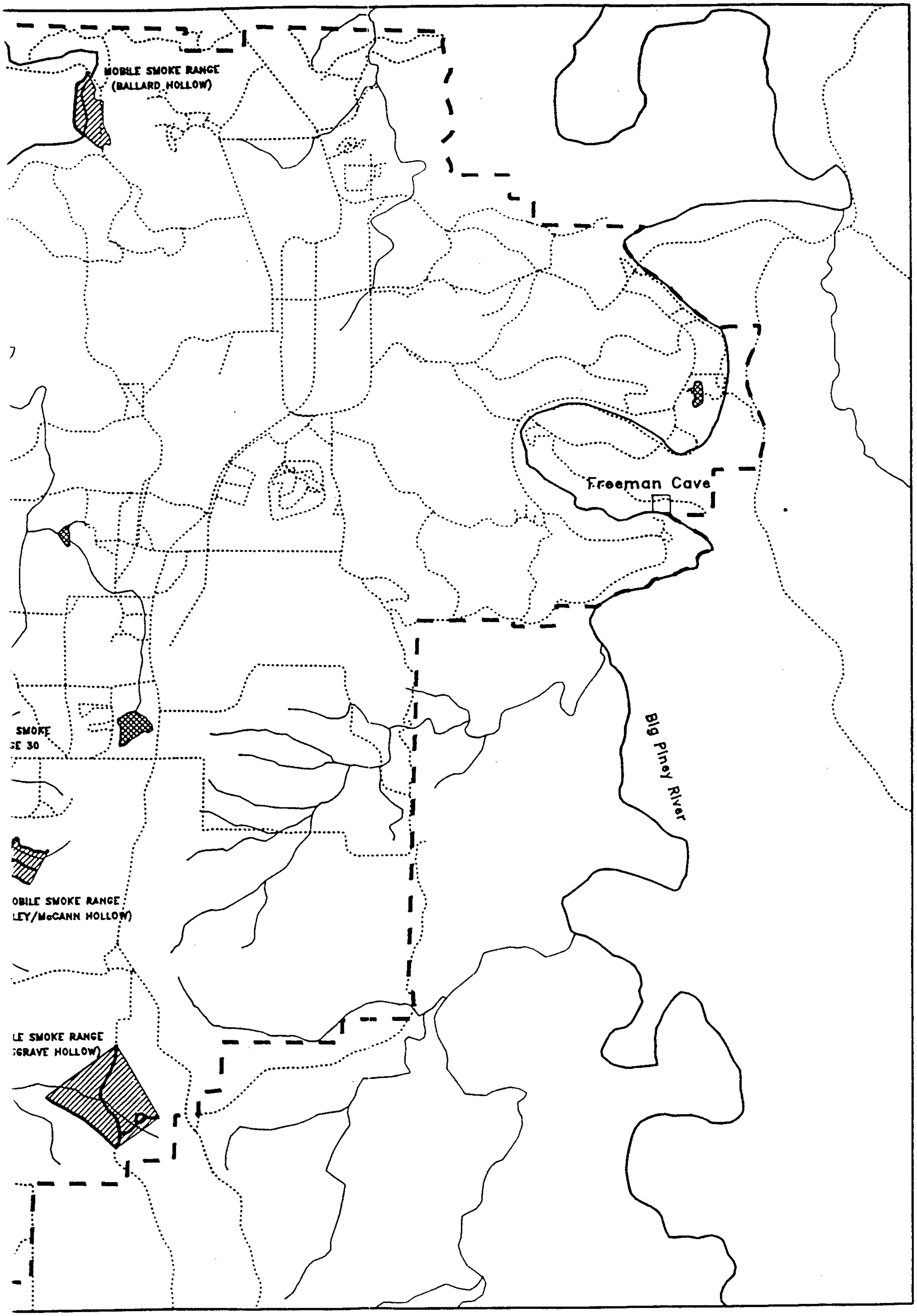


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FIGURE 5-

proposed fo

areas at For

Gray Ba

Indiana
Gray Ba

Mobile

Mobile

Fort Leo

Road

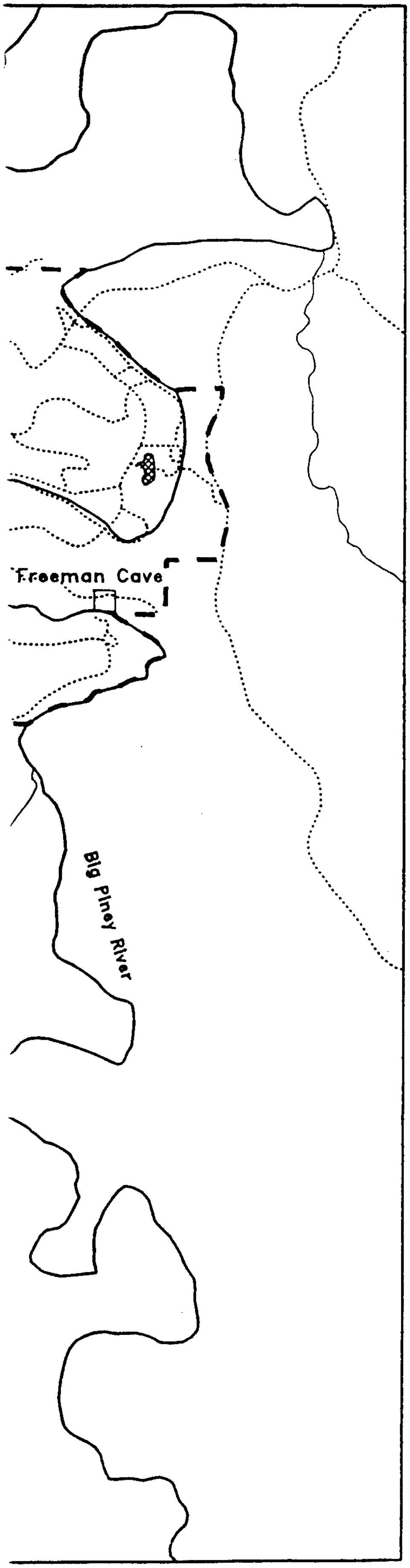
Pond

River /

0

3D/EI

②



BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

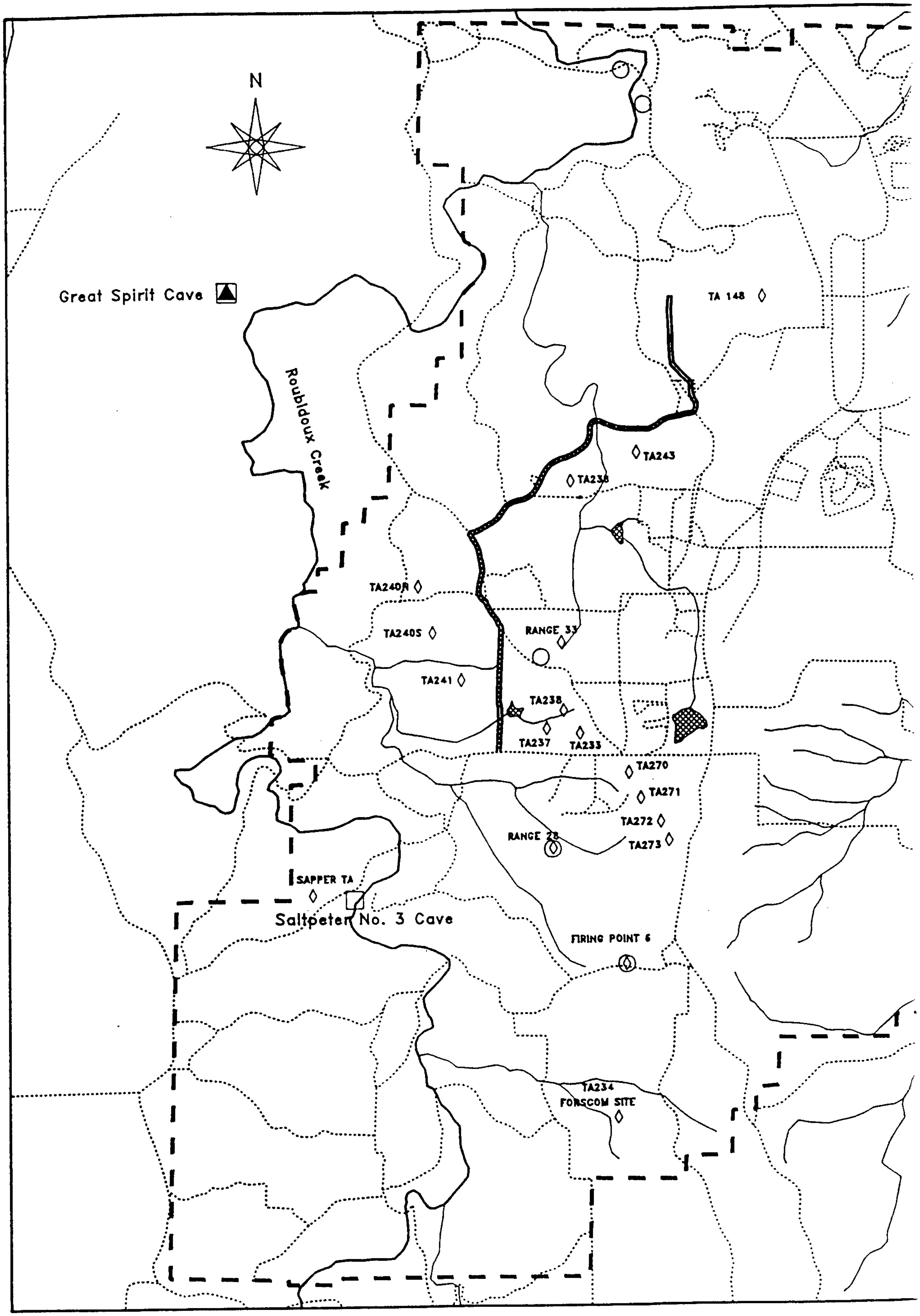
FIGURE 5-4. Gray bat caves and proposed fog oil smoke training areas at Fort Leonard Wood, Missouri.

Gray Bat Cave
Indiana Bat Hibernaculum/ Gray Bat Cave
Mobile Smoke Training Area
Mobile Smoke Deployment Road
Fort Leonard Wood Boundary
Road
Pond
River / Stream

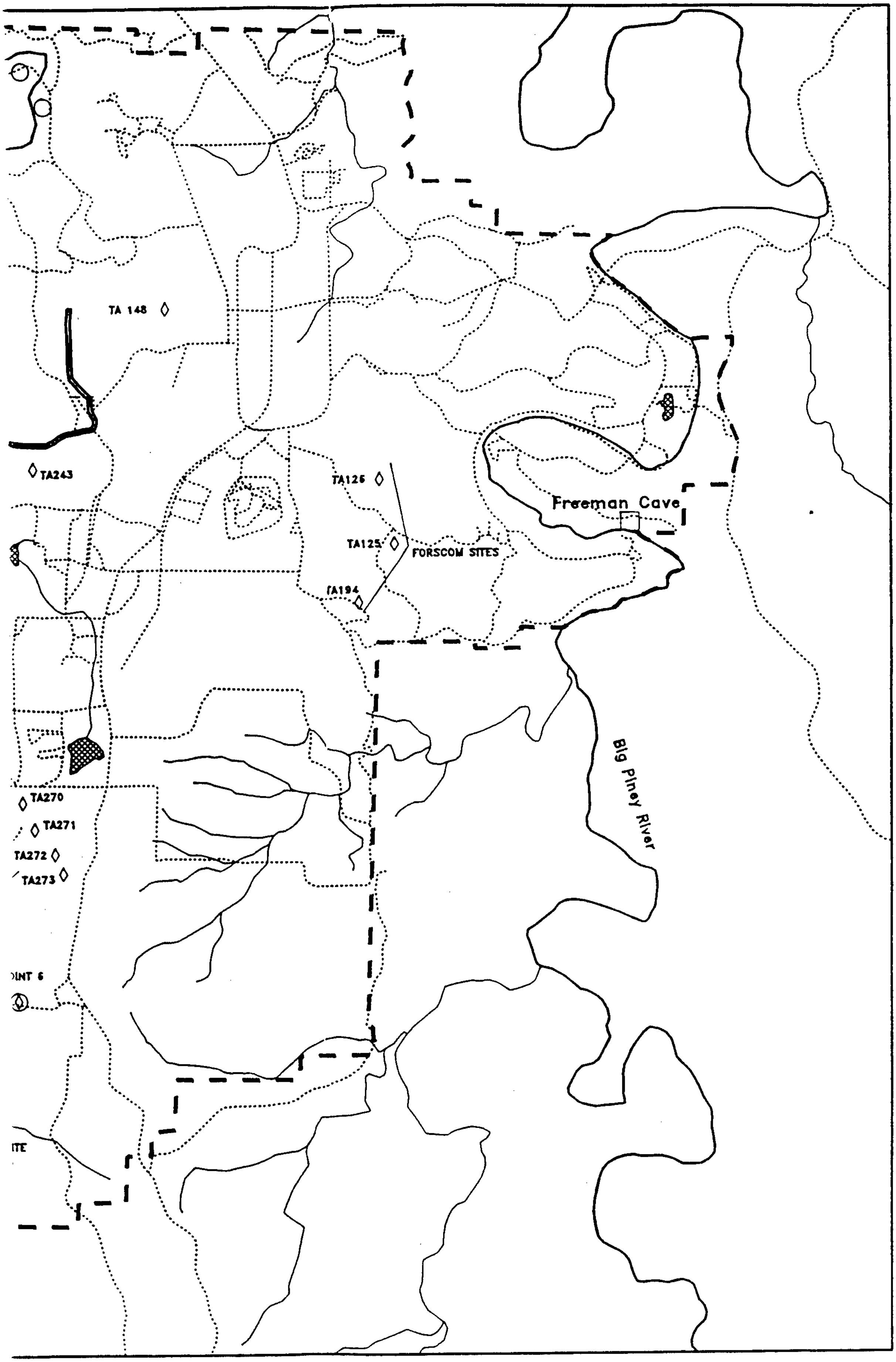
Kilometers
0 2 4

3D/ENVIRONMENTAL

3



N
Great Spirit Cave
Roubidoux Creek
TA 148
TA243
TA236
TA240R
TA240S
RANGE 33
TA241
TA238
TA237
TA233
TA270
TA271
TA272
TA273
RANGE 28
SAPPER TA
Saltpeter No. 3 Cave
FIRING POINT 6
TA234
FORSCOM SITE



BIOLOGICAL
RELOCATION OF
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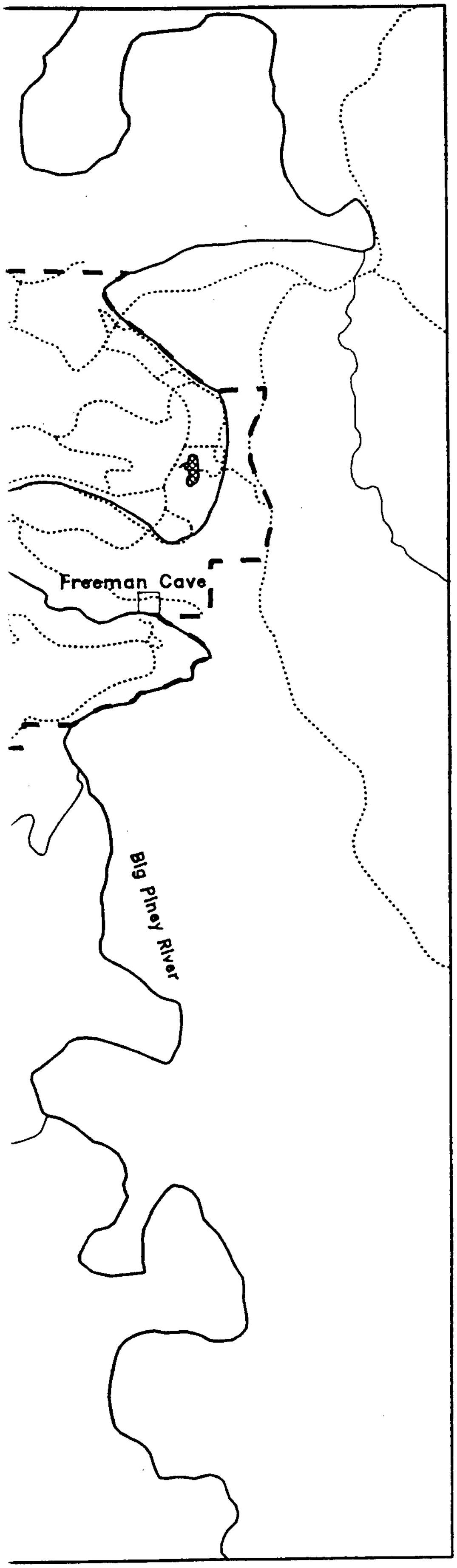
FIGURE 5-5.
proposed smoke p
training locations
Missouri.

Gray Bat Cav
Indiana Bat H
Gray Bat Cav
Smoke Pot U
Smoke Grena
Smoke Grena
Fort Leonard
Road
Pond
River / Strea

Kil
0

3D/ENVIF



BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 5-5. Gray bat caves and proposed smoke pot and smoke grenade training locations at Fort Leonard Wood, Missouri.

□ Gray Bat Cave

Indiana Bat Hibernaculum/ Gray Bat Cave

○ Smoke Pot Use Area

◊ Smoke Grenade Use Area

Smoke Grenade Training Road

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers

0 2 4

3D/ENVIRONMENTAL

3

Common test species (e.g. rats, mice, guinea pigs) may demonstrate different effects than can be expected in bats. "Critical Effects" listed in Appendix IV, Attachments G are effects manifested by test species, not gray bats. Where we predict receptors will be exposed to unsafe concentrations, we do not necessarily expect Critical Effects will result. We list Critical Effects as a reference only. Inferences from Critical Effects must be made with caution. Our description of specific effects likely to be manifested by gray bats is limited by available toxicity data.

Development of acute and chronic toxicity values for the receptors in this analysis is beyond the scope of this Biological Assessment. These tests, if completed for the numerous potential contaminants evaluated, are expensive, time consuming. It is common practice to extrapolate toxicity values from test species to the species of interest.

Section 4.1.2.3 of this BA; Appendix IV, Section 5.3; and Appendix IV, Attachment I, Table I-5 provides general background information on each of the stressors evaluated in detail, and describes the magnitude of proposed stressor use. Section 4.1.2.3 describes indirect effects of fog oil and TPA to endangered bats through aquatic pathways.

5.1.3 Management Guidelines

Detailed management guidelines for gray bats are contained in Section 5.1.3 of the Biological Assessment for the Master Plan and Ongoing Mission at Fort Leonard Wood, Missouri (3D/Environmental 1996a). That narrative is incorporated by reference.

Fort Leonard Wood maintains zones of specialized management for gray bats around Saltpeter No. 3 Cave (see Section 5.1.3 of Ongoing Mission BA). With this biological assessment and associated Environmental Impact Statement, Fort Leonard Wood creates an identical set of management zones (Restricted Zone, Zone 1, Zone 2) around Freeman Cave. Specifics of this management action are described in Section 2.2 of this document.

5.2 EFFECTS ANALYSIS AREA

In general, effects to gray bats within the Fort Leonard Wood boundary are assessed. Where the effects of specific activities extend beyond the Installation boundary, impacts to gray bats or important gray bat habitat are addressed.

5.3 AFFECTED HABITAT DESCRIPTION

A detailed description of the physical environment on the Installation, including topography, physiology, climate, geology, seismicity, soils, air quality, water resources, and vegetation is contained in Section 5 of the Environmental Assessment of the Master Plan and Ongoing Mission (Harland Bartholomew and Associates 1995). The description of these resources is incorporated here.

Descriptions of gray bat populations and use of Saltpeter No. 3 Cave, Great Spirit Cave, and Freeman Cave are provided in Section 5.3 of the Biological Assessment for the Master Plan and Ongoing Mission (3D/Environmental 1996a). These descriptions are incorporated by reference.

5.4 STUDY METHODS

5.4.1 Effect of BRAC-Related Construction to Gray Bat Summer Habitat

We assessed the location of proposed construction in areas of suitable gray bat habitat. Specifically, we assessed impacts of construction to habitat within 162 meters of gray bat maternity caves and to wooded habitat between maternity caves and nearby riparian habitat. Section 5.1.3 of the Ongoing Mission Biological Assessment (3D/Environmental 1996a) describes existing habitat management guidelines on the Installation, including the 162 meter radius restricted zone around certain caves used by bats. Forest clearing within 30 m of surface water impoundments was evaluated to determine impacts to gray bat foraging habitat. Construction impacts to forested riparian areas within 30 m of stream channels providing suitable flight/foraging corridors also were assessed. Suitable flight corridors were defined by the presence of unobstructed space between the stream channel and the forest canopy.

5.4.2 Effect of BRAC-Related Sound on Non-Hibernating Gray Bats

Methods used to record, characterize, and model sounds are described in Sections 4.4.5.1, 4.4.5.2, and 4.4.5.4 of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). These methods are incorporated by reference.

Potential impacts of sound generated by proposed smoke training to non-hibernating gray bats on Fort Leonard Wood were assessed by consulting current literature. The literature survey revealed little relevant information about effects of sound and vibration on gray bats for Fort Leonard Wood's Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). Because little information in the primary literature is written directly about gray bats, the literature review for this assessment was expanded to include data regarding other species.

To gather information on potential impacts of sound to gray bats, we searched scientific, medical, and agricultural databases at the University of Tennessee, University of Cincinnati, Miami University, and Indiana University. Electronic resources of the University of Cincinnati (e.g., OhioLink) allow access to the holdings of most other colleges and universities in Ohio. References from across the nation were requested through inter-library loan.

We attempted to locate scientific publications, dissertations, books, proceedings of meetings, and other printed material. Key words were used to query each database. Names of authors specializing in auditory research also were used to locate information. Applicable documents were obtained and reviewed.

5.4.2.1 Measuring and Recording Sounds and Seismic Vibrations

Unweighted overall sound pressure levels for M56 smoke generators and M157 smoke generators were measured. Techniques for measuring and recording sounds are described in Section 4.1.4.5.1 of the Biological Assessment for the Master Plan and Ongoing Mission at Fort Leonard Wood (3D/Environmental 1996a). These methods are hereby incorporated by reference to limit redundancy.

5.4.2.2 Characterizing Sounds and Seismic Vibrations

Methods used to characterize sounds are described in Section 4.1.4.5.2 of the Biological Assessment for Indiana Bats, Gray Bats, and Bald Eagles at Fort Leonard Wood, Missouri (3D/Environmental 1996a). These methods are hereby incorporated by reference to limit redundancy.

5.4.2.3 Modeling Sound and Seismic Propagation

Techniques for modeling of sound propagation are described in Section 4.1.4.5.4 of the Biological Assessment for Indiana Bats, Gray Bats, and Bald Eagles at Fort Leonard Wood, Missouri (3D/Environmental 1996a). These methods are hereby incorporated by reference to limit redundancy.

5.4.3 Effect of Toxicological Agents

Methods employed to assess effects of toxicological agents are described in Section 4.4.3.

5.5 RESULTS

5.5.1 Effect of BRAC-Related Construction to Gray Bat Summer Habitat

No proposed construction projects are proposed within 162 meters (the Installation's "Restricted Zone") of Saltpeter No. 3 Cave or Freeman Cave (Figure 5-2). Wooded tracts between these caves and nearby riparian areas will not be affected. No clearing of forest within 30 m of surface water impoundments will occur.

Six projects are proposed within wooded riparian areas or within 30 m of permanent streams lacking streamside forest. Two activities will result in clearing of streamside forest. Construction of the Military Police OSUT will result in clearing of 7.5 acres of forest including a segment adjacent to a stream. This will result in clearing forest along 300 m of riparian forest along the north side of the stream, with total loss of 1.48 acres of gray bat foraging habitat. A forested strip 10 meters wide will remain along the stream. Construction for two road crossings for mobile smoke training in Bailey-McCann Hollow will eliminate 6.4 acres of forest. This construction will result in removal of trees along both sides of approximately 20 m of stream for each of two road crossings, resulting in a total loss of 0.4 acres of gray bat foraging habitat.

Three projects include construction of stream crossings at sites lacking riparian forest. Construction for mobile smoke training on Ballard Range includes a crossing of Roubidoux Creek. Minor road construction in the Cannon Range will create a permanent stream crossing in a previously cleared area. Construction of the Flame Range on Range 27A will involve construction

of an access road into Range 27. This road will cross an already cleared stream. Construction will occur only during daylight hours. One project will eliminate riparian forest along a stream lacking a suitable flight corridor.

5.5.2 Effect of BRAC-Related Sound on Non-Hibernating Gray Bats

M56 and M157 smoke generators produce at source sound pressure levels (SPLs) of 122 dB and 112 dB, respectively. For both the M56 and M157, we examined 12 generators running simultaneously on mobile smoke training areas. The closest proposed mobile smoke training areas to Saltpeter No. 3 Cave is approximately 1750 m. At that distance, sound from smoke generators (both M56 and M157) is estimated from sound modeling (Appendix II) to be 1 dB or less above background sound levels (see 3D/Environmental 1996a for a detailed discussion of background sound levels). At 2420 m from Davis No. 2 Cave, sound from the proposed mobile smoke training area at Bailey/McCann Hollow will also be 1 dB or less above background sound levels.

An important factor in assessing potential impacts of sound stimuli to non-hibernating bats is determining hearing ability. Hearing ability is an important component of perception and may also be important in susceptibility for auditory damage. Our queries were focused on determining gray bat hearing ability, particularly in predominant frequency range generated by training activities (25 Hz to 20,000 Hz). We also assessed damage from intense sound in that frequency range, and determining if reports exist of sound stimuli causing disturbance to any non-hibernating bat species.

We searched 43 keywords and phrases on bat audition, disturbance, and noise effects on wildlife. We also queried citations for 13 authors who conduct research in bat audition and noise effects on wildlife. Only 28 papers were found in our database search which had apparently relevant titles.

Sixty-one papers were examined in detail, most of which had only indirect relevance. Because of the paucity of published data to support an analysis of potential impacts of sound stimuli to non-hibernating bats, we spoke with leading scientists in the field of hearing research who specialize in bats or who have conducted work on audition in bats. We contacted scientists listed in Table 5-2 to discuss hearing abilities of microchiropteran bats and the potential for

TABLE 5-2. Researchers queried for information concerning hearing in gray bats and other *Myotis,* and potential disturbances from sound stimuli to non-hibernating bats.

Researcher	Institution Affiliation
Wong, D.	Indiana University
Wenstrup, J.	Northeastern Ohio's College of Medicine
Heffner, R.	University of Toledo (Ohio)
Fuzessery, Z.	University of Wyoming
Masters, M.	Ohio State University
Henson, M.	University of North Carolina Chapel Hill
Suthers, R.	Indiana University

disturbance and auditory damage caused by sound. The discussion below reflects those contacts with important topics referenced as appropriate.

5.5.3 Effect of Toxicological Agents

Information pertinent to this toxicological evaluation describing seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history are provided in Section III of Appendix IV. Descriptions of local geomorphology, soils, groundwater, surface water, climate, and natural resources are provided in Section IV of Appendix IV.

5.5.3.1 Fog Oil

Toxicity

Chemical properties and a general description of fog oil is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of fog oil via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when gray bats

forage. Gray bats may also be exposed to stressors in maternity caves. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of fog oil in air, and the rate at which fog oil is deposited in various atmospheric conditions are described in Appendix IV, Section VIII. Figures 4-9 and 4-10 of this BA are representative examples of fog oil dispersion from static and mobile smoke training areas in Pasquill atmospheric stability category E. Dispersion of fog oil in Pasquill categories B - E is described and plotted in Appendix IV, Section VIII. Figures 4-11 and 4-12 of this BA are representative examples of fog oil deposition downwind of static and mobile training areas in Pasquill atmospheric stability category E. Additional estimates of fog oil deposition are provided in Appendix IV, Attachment B. Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are included in Appendix IV, Attachment D.

Risk

The risk of acute and chronic effects (at varying distances from the fog oil source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment G. Effects to gray bats are anticipated where the ratio of anticipated exposure (dose) to safe exposure (dose) exceeds 1.0. Effects to gray bats are summarized in Table 4-12.

5.5.3.2 Terephthalic Acid

Toxicity

Chemical properties and a general description of terephthalic acid is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of TPA via ingestion, dermal

absorption, and inhalation exposure. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.2.6.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. Exposure may occur nearly installation-wide when gray bats forage. Gray bats in maternity caves also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of TPA in air is described in Appendix IV, Section VIII. The dispersion of TPA from grenades and smoke pots was modeled for Pasquill atmospheric stability category B (Figures 4-13 and 4-14). Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment D.

Risk

The risk of acute and chronic effects (at varying distances from the TPA source, and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment G. Effects to gray bats are anticipated when Hazard Quotients (HQ) exceed 1.0 (see Appendix IV). Effects of proposed TPA training on gray bats are summarized in Table 4-12.

5.5.3.3 Titanium Dioxide

Toxicity

Chemical properties and a general description of titanium dioxide are provided in Appendix IV, Section V. Section 7.5 of Appendix IV describes toxicity of titanium dioxide via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of titanium dioxide are discussed in Appendix IV, Section 7.5.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when gray bats forage. Gray bats in maternity caves also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of titanium dioxide in air was modeled for Pasquill category E (Figure 4-15). Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment D.

Risk

The risk of acute and chronic effects (at varying distances from the titanium dioxide source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment G. Effects to gray bats are anticipated where HQs exceed 1.0. Effects to gray bats are summarized in Table 4-12.

5.6 EFFECTS ANALYSIS/DISCUSSION

5.6.1 Effect of BRAC-Related Construction to Gray Bat Summer Habitat

Construction proposed to support the new mission at Fort Leonard Wood will not affect Saltpeter No. 3 Cave or Freeman Cave, nor the wooded habitat between these caves and nearby riparian areas. No forest within 30 m of surface water impoundments will be cleared as a result of BRAC construction.

Construction activities will result in removal of riparian forest in two locations and may eliminate gray bat foraging habitat. Forest removal along streams resulting from proposed construction may reduce foraging habitat quality for gray bats through changes in canopy cover and prey abundance. Construction along previously cleared streams is unlikely to alter gray bat foraging habitat quality. Construction of the MP OSUT will clear 300 m along one side of a stream, resulting in the loss of 2.26 acres of gray bat foraging habitat. Construction of a mobile smoke training road in Bailey-McCann Mobile Smoke Training Area includes two stream crossings, each resulting in clearing of 0.2 acres of streamside forest. Other stream crossings involved with BRAC construction will not result in forest clearing. Loss of gray bat foraging habitat from BRAC construction totals 2.26 acres.

It is not possible to calculate the number of gray bats affected by the loss of 2.26 acres of habitat. Gray bats using the affected area may alter their foraging location or behavior. Foraging efficiency of gray bats using the cleared areas may be reduced. The clearing may increase the likelihood gray bats in the area will be preyed upon.

5.6.2 Effect of BRAC-Related Sound on Non-Hibernating Gray Bats

No information was discovered from literature to support a conclusion that sound stimuli (with characteristics of those reaching Fort Leonard Wood's gray bat caves) might impact cave roosting gray bats. The following discussion examines the hearing ability of gray bats (and other *Myotis*) as related to auditory perception of sounds generated by training.

Various aspects of hearing abilities in bats are well studied. For overviews and general discussions the reader is referred to reviews by Henson (1970), Novick (1970), and Fenton (1985). One method of determining hearing ability is to develop an audiogram. Many different

techniques can be employed, but typically responses are measured in auditory nerves or other neural tissue (e.g., N_4) in response to a series of sounds played to an organism (or tissue preparation) at different frequencies and intensities. The resulting plot of the threshold level required to induce a response versus the different frequencies presented is called an audiogram.

Each technique of creating an audiogram measures a different level of sound processing in the auditory pathway. The closer to the ear the measurement is made, the lower the level of processing. Neural audiograms assess the lower levels of processing, the response of a nerve or group of nerves to sounds. Behavioral audiograms assess the behavioral response to sounds, which is the highest level of processing. While an auditory nerve may be triggered by a particular frequency and intensity, the response may attenuate as it travels through the nervous system. When a sound stimulus is presented, the animal must not only detect the signal with its ear, but the signal must travel through the nervous system and be recognized as requiring a behavioral response (i.e., the signal goes through higher levels of neural processing). Authors use different techniques for obtaining audiograms, but the frequency patterns of various techniques generally are similar (e.g., Figure 5-6).

Neural and behavioral audiograms for the little brown bat, *Myotis lucifugus*, characterize hearing ability of this species (Figure 5-6). There is sensitivity for frequencies ranging from 10 kilohertz (kHz) to 130 kHz with greater sensitivity for frequencies less than 80 kHz. The frequency range to which little brown bats are most sensitive (i.e., the frequency with the lowest threshold) is between 35 and 40 kHz. Dalland (1965) found no behavioral evidence that *Myotis* hear sounds below 10 kHz, although the lower frequency limit of *Myotis* has not been established conclusively (Henson 1970). Long and Schnitzler (1975) stated all reliable evidence indicates microchiropteran bats have poor hearing ability at low frequencies. R. Heffner (pers. comm. March 6, 1996) confirmed that bats have poor sensitivity to sound below 10 kHz.

No published audiogram for gray bats was discovered in our literature review or contacts with bat researchers. Shimozawa et al. (1974) compared orientation sounds and audiograms (unpublished data) of gray bats to those of little brown bats and found no noticeable differences. Echolocation signals of little brown and gray bats are similar, suggesting hearing ability of the two species is similar (Figure 5-7). Long and Schnitzler (1975) observed close association between the dominant frequencies of echolocation signals and frequency sensitivity peaks in audiograms.

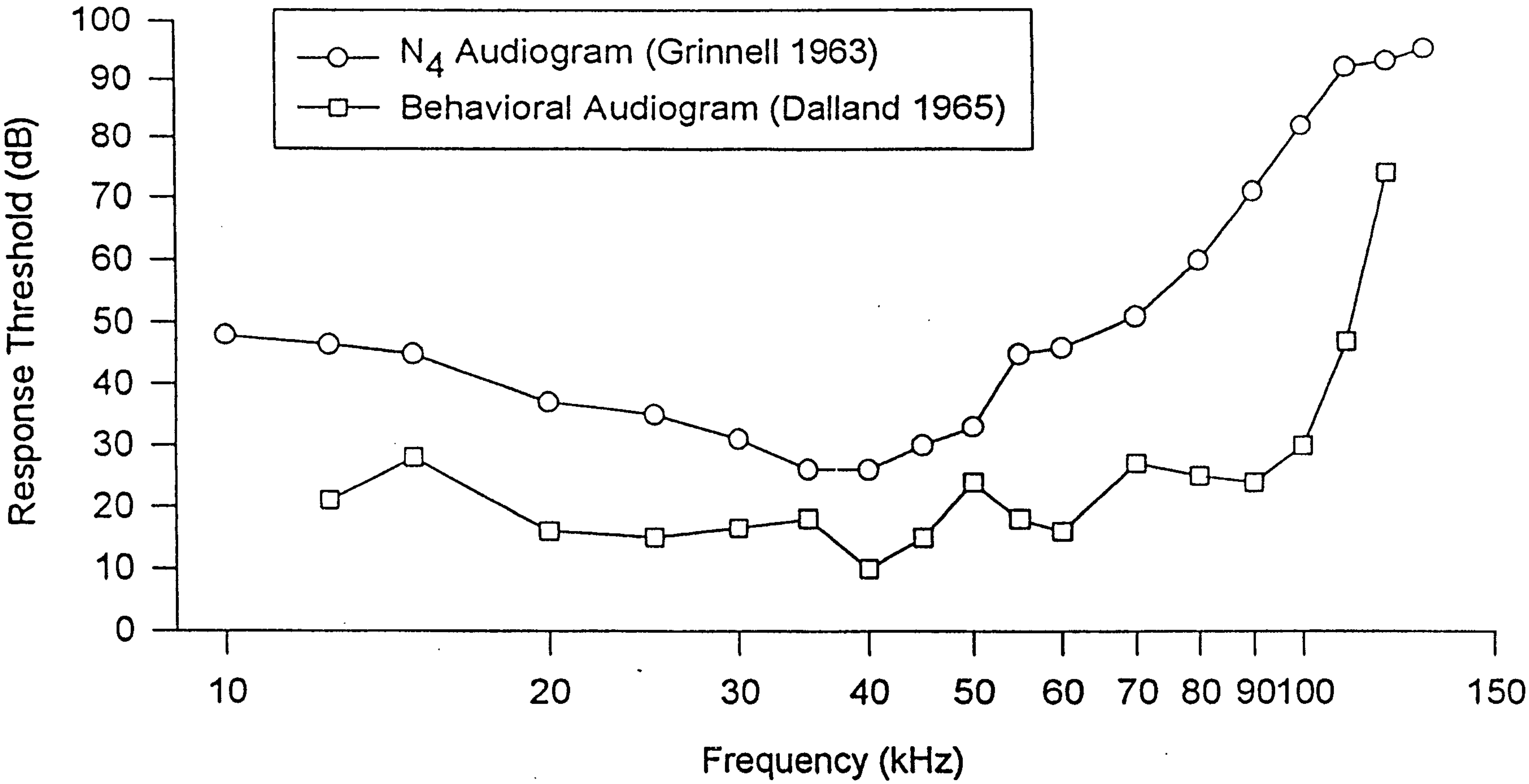


FIGURE 5-6. Audiograms for the little brown bat, *Myotis lucifugus*, showing sound thresholds eliciting a response. N_4 (4th space of Nuel in the Organ of Corti) audiogram was developed from electrical potentials measured in intercellular spaces of the cochlear membrane. Behavioral audiogram was developed from trained behavioral responses to detected sound.

FIGURE 5-7. Comparison of call sonograms of little brown bats and gray bats.

The evidence supports the assumption that these species have similar hearing abilities, at least with respect to the range of audible frequencies.

Sounds generated by BRAC-related training activities are predominantly in the sonic (16 to 20,000 Hz) frequency ranges (Appendix I). Although the M56 smoke generator may produce sound in the ultrasonic range (above 20 kHz), ultrasound attenuates quickly and will not reach gray bat caves. This topic was discussed in detail in Section 4.5.6.3 of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). That discussion is incorporated by reference.

In conclusion, all evidence suggests that *Myotis* (including gray bats) do not hear well in the frequency ranges of sound generated by BRAC-related training activities and therefore are not likely to be disturbed by these sound stimuli alone.

Although hearing sensitivity of gray bats to low frequencies is poor, the risk of auditory damage, considering military training often generates intense sound, cannot be immediately ruled out. Potential negative effects of intense sound were described in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). That discussion is incorporated by reference.

Price (1977) suggested damage from intense acoustic impulses might depend upon the location of the energy in the impulse's spectral peak and its relation to the frequency to which the ear is best tuned. In subsequent experiments with cats, whose ears are best tuned at about 4 kHz, Price et al. (1989) and Price (1986) showed low frequency impulses (80 to 100 Hz at exposures of 154 to 166 dB) were less hazardous than mid-range frequencies of 4 kHz at exposures of 135 to 145 dB (Price and Wansack 1989). BRAC-related sounds (Appendix I) contain mainly mid-range frequencies, and would reach gray bat caves on Fort Leonard Wood at levels close to background. Given the above discussion showing peak frequency sensitivity for gray bats of 40 kHz (which decreases their susceptibility to damage from lower frequency sound), we find it unlikely that BRAC-related sounds would result in auditory damage to gray bats in caves on Fort Leonard Wood.

Therefore, we conclude that gray bats probably hear very little sound generated by BRAC-related training activities on Fort Leonard Wood. Gray bats are also unlikely to suffer auditory damage from sounds generated by BRAC-related training on Fort Leonard Wood.

5.6.3 Effect of Toxicological Agents

A number of proposed training activities may expose gray bats to unsafe concentrations of stressors. We assessed the potential for acute and chronic effects. The discussion below focuses upon effects summarized in Table 4-12. We provide a gross estimate of the number of bats to be affected where we predict effects. Estimates of the number of bats to be affected are based upon the following assumptions:

- Pregnant gray bats occur in 3 caves on, or near, Fort Leonard Wood. Where unsafe stressor concentrations reach Great Spirit or Saltpeter No. 3 maternity caves, we assume all gray bats in the caves will be affected. We base estimates of gray bat numbers in these caves on surveys completed in 1994 (Table 5-1). The number of reproductively active female gray bats, and juvenile gray bats in Freeman Cave has not been documented. We believe the number of pregnant gray bats in Freeman Cave is low.

- We assume foraging gray bats occur installation-wide.

5.6.3.1 Static Fog Oil Training

Acute Effects

Under conditions we assessed, a single exposure to fog oil generated during static training will not affect foraging or roosting gray bats through ingestion, inhalation, or dermal absorption.

Chronic Effects

Gray bats foraging within 4000 m of static smoke training areas may inhale unsafe concentrations of fog oil resulting in chronic inhalation effects. Up to approximately 15,990 foraging gray bats may be affected.

Gray bats roosting in Saltpeter No. 3 Cave may inhale unsafe concentrations of fog oil from static training resulting in chronic inhalation effects. A 1994 survey documented approximately 3740 gray bats in the maternity colony in Saltpeter No. 3 Cave.

5.6.3.2 Mobile Fog Oil Training

Acute Effects

A single exposure to fog oil generated during mobile training will not affect foraging gray bats through ingestion, inhalation, or dermal absorption.

Chronic Effects

Under conditions we assessed, repeated exposures (over an individual bats life span) to fog oil generated during mobile training will affect gray bats via inhalation. Gray bats foraging within 7000 m of mobile smoke training areas may be affected. Up to approximately 15,990 foraging gray bats may suffer chronic effects.

Gray bats in Saltpeter No. 3 Cave will inhale unsafe doses of fog oil generated on Musgrave, Bailey/McCann, and Cannon Range (Mush Paddle Hollow) mobile smoke training areas that will result in chronic effects. A 1994 census documented 3740 gray bats in the Saltpeter No. 3 maternity colony.

5.6.3.3 Terephthalic Acid Grenades

Acute Effects

Under conditions we assessed, a single exposure to TPA will affect gray bats through inhalation. Gray bats foraging within 3000 m of the source will be affected. As many as 19730 gray bats may be exposed while foraging.

Gray bats in Saltpeter No. 3 Cave will inhale unsafe concentrations of TPA from grenades deployed at the Sapper TA (Table 4-12). Up to approximately 3740 gray bats may be exposed while in Saltpeter No. 3 Cave.

Chronic Effects

TPA grenades may cause chronic effects in the same locations as described above for acute effects (Table 4-12). Identical numbers of foraging gray bats, and gray bats in maternity caves may be affected (Figure 5-5).

The assessment of chronic effects evaluated worst-case exposure in that we assumed individual gray bats would be exposed to TPA each time it is released, regardless of wind direction. We assumed all releases would occur during the portion of the year when bats are present on the installation. However, TPA grenades will also be used when bats are absent from the installation, therefore the number of exposures may be lower than the number we assessed. For example, we assessed effects of exposure to 3136 TPA grenades. If actual exposures result from 120 or fewer grenades, there will be no chronic effects.

5.6.3.4 Terephthalic Acid Smoke Pots

Acute Effects

Under conditions we assessed, gray bats may inhale unsafe concentrations of TPA from smoke pots. Gray bats foraging within 3000 m of TPA smoke pot deployment sites may be affected by a single exposure. As many as 19,730 gray bats may be exposed while foraging.

Gray bats in Saltpeter No. 3 Cave may inhale toxic concentrations of TPA from a single exposure due to smoke pots deployed on Cannon Range (Mush Paddle Hollow) and Bailey/McCann Hollow mobile smoke training areas (Table 4-12). Up to approximately 3740 gray bats may be exposed while in Saltpeter No. 3 Cave.

Chronic Effects

TPA smoke pots may cause chronic effects in the same locations as described above for acute effects (Table 4-12). Identical numbers of gray bats may be affected.

The assessment of chronic effects evaluated worst-case exposure in that we assumed individual gray bats would be exposed to TPA each time smoke pots are released, regardless of wind direction. We assumed all releases would occur when bats are present on the installation. However, TPA smoke pots will also be used during portions of the year when gray bats are absent from the installation, therefore the number of exposures may be lower than the number we assessed. For example, we assessed effects of exposure to 950 TPA smoke pots. If actual exposures result from 120 or fewer smoke pots, there will be no chronic effects.

5.6.3.5 Titanium Dioxide Grenades

Acute Effects

No acute effects are expected.

Chronic Effects

No chronic effects are expected.

5.6.4 Cumulative Effects

Effects of the proposed action are described in this biological assessment. Effects of the ongoing mission at Fort Leonard Wood are described in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a).

Future federal activities in the action area not analyzed in this Biological Assessment, or the Biological Assessment of the Ongoing Mission, require action-specific assessment for Endangered Species Act compliance. No non-federal actions affecting gray bats are reasonably certain to occur within the action area. No cumulative effects are anticipated.

5.7 STATEMENT OF FINDING

5.7.1 Effect of BRAC-Related Construction to Gray Bat Summer Habitat

Proposed construction activities are not expected to kill or injure gray bats. The activities may affect gray bat foraging habitat.

Proposed construction activities are not expected to affect gray bat maternity caves.

Proposed development of forest management guidelines will beneficially affect summer habitat of the gray bat.

5.7.2 Effect of BRAC-Related Sound on Non-Hibernating Gray Bats

Sound generated by BRAC activity will not affect gray bats in Saltpeter No. 3 or Freeman caves.

5.7.3 Effect of Toxicological Agents

Under the conditions we assessed, fog oil, TPA grenades, and TPA smoke pots may affect gray bats. If conditions vary from those we used to model dispersion, it is likely the expected effects may decrease.

Section 6
Bald Eagle (*Haliaeetus leucocephalus*)

Section 6:

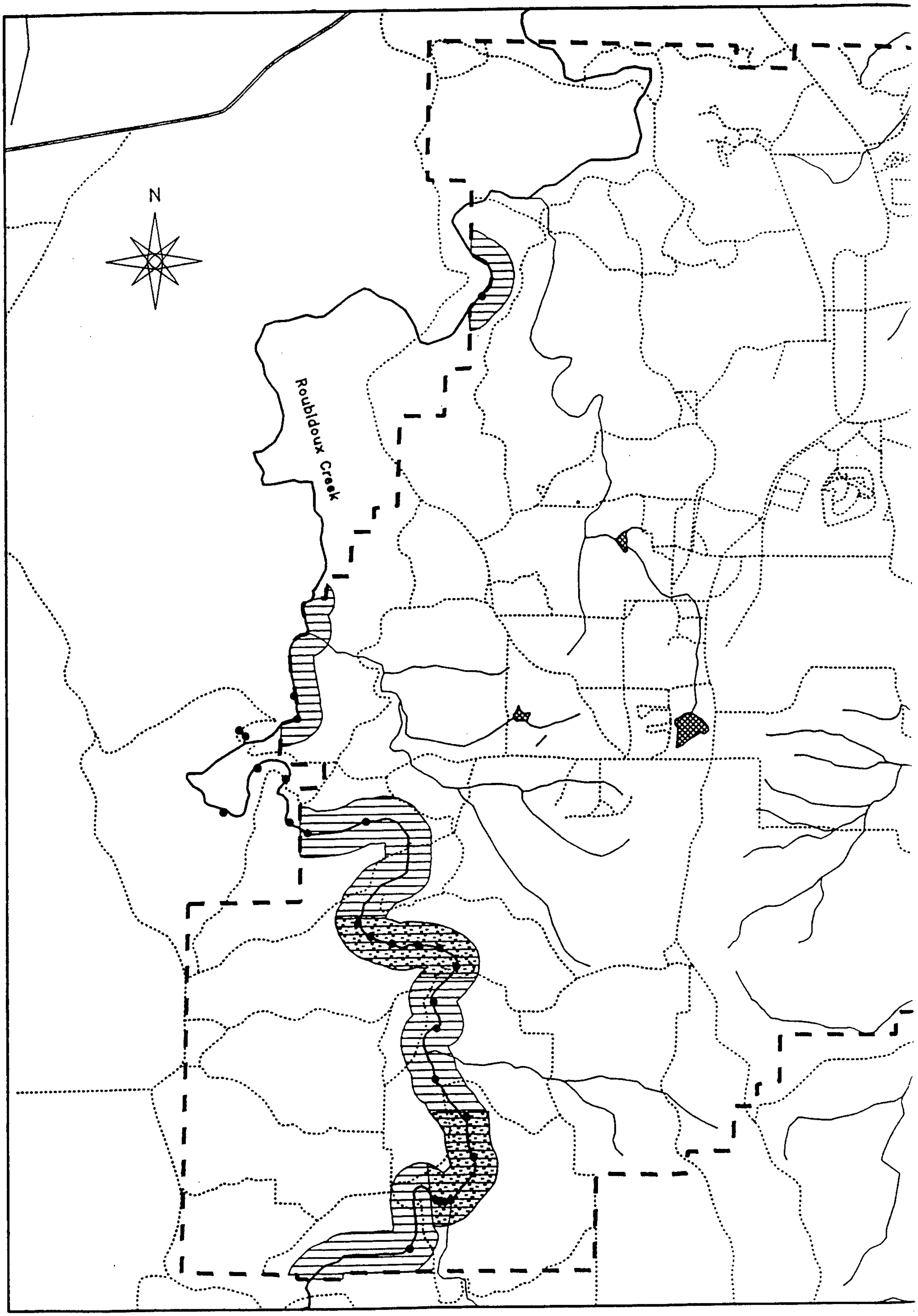
Bald Eagle (Haliaeetus leucocephalus)

6.1 BACKGROUND

3D/Environmental provides a detailed description of the species in the Biological Assessment of the Master Plan and Ongoing Mission (1996a). Section 6 of that document describes the species' legal status, life history, geographic range and existing Installation management guidelines. We incorporate those narratives by reference.

6.1.1 Bald Eagles on Fort Leonard Wood

Bald eagles have been observed on Fort Leonard Wood only during the winter (Figure 6-1). In cooperation with the FWS and the Missouri Department of Conservation (MDC), the Installation has conducted annual winter surveys for bald eagles in Pulaski County, Missouri, since 1976. Surveys were not completed in 1980, 1992, and 1994. In 1996, a survey was conducted from roads in the northeast portion of the Installation and surrounding lands; an aerial survey of Pulaski County was not done. The road survey in 1996 found 5 eagles on or immediately adjacent to Fort Leonard Wood. This number is not directly comparable to data obtained from prior aerial surveys of the installation and Pulaski County, and does not support modification of the statistical population trend analysis described in Section 6.1.1 of the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a).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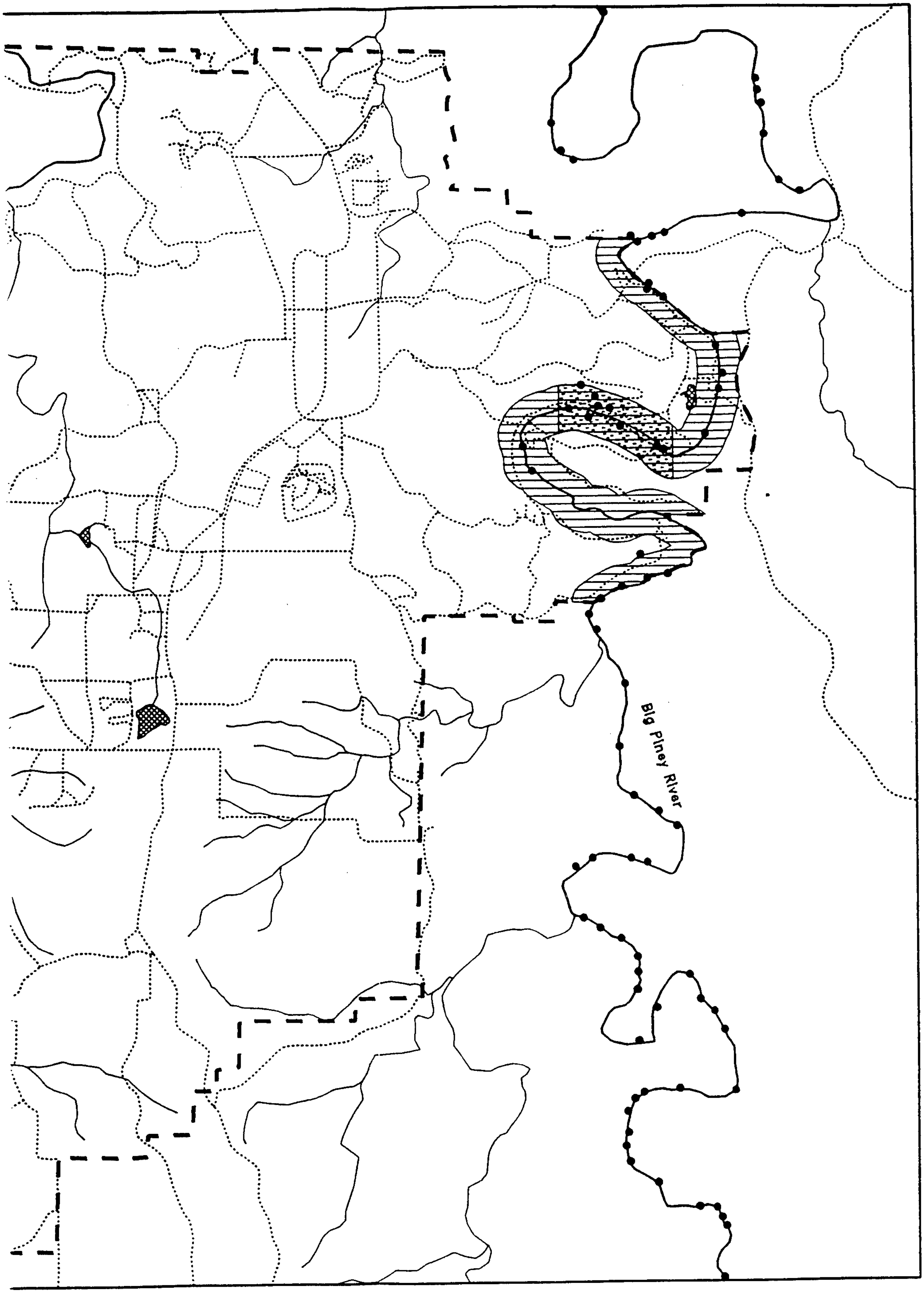

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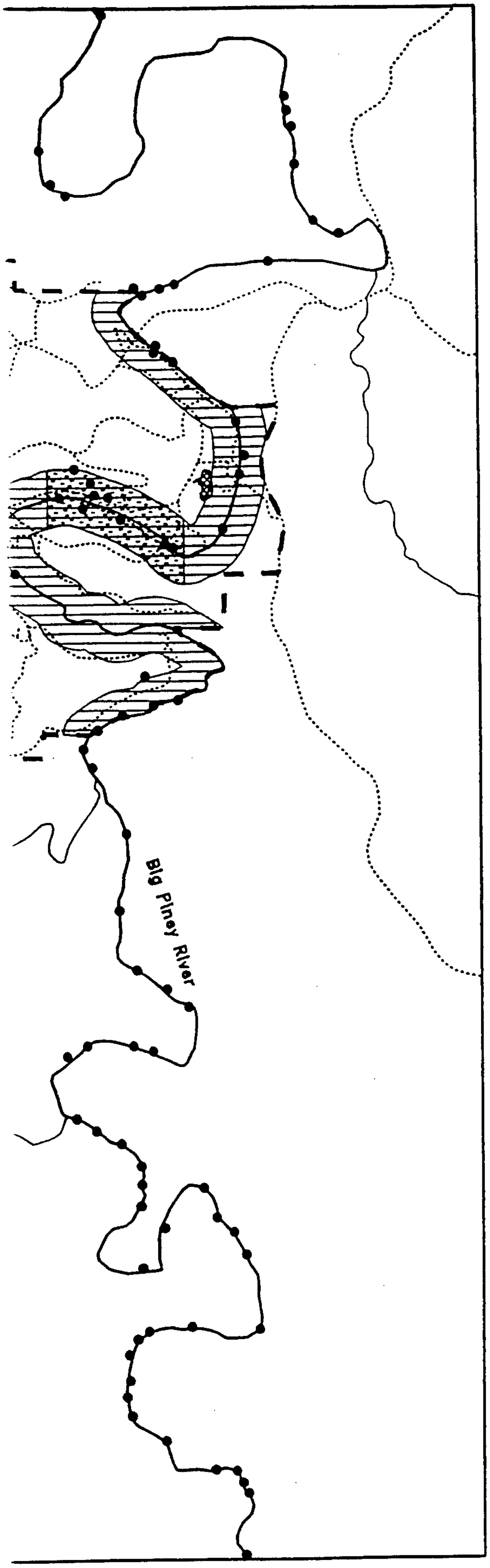


BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6-1. Bald eagle winter occurrences, use areas, and concentration areas on or near Fort Leonard Wood, Missouri.

- Bald Eagle Sighting
- Bald Eagle Use Area
- Bald Eagle Concentration Area
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream

Kilometers

0 2 4

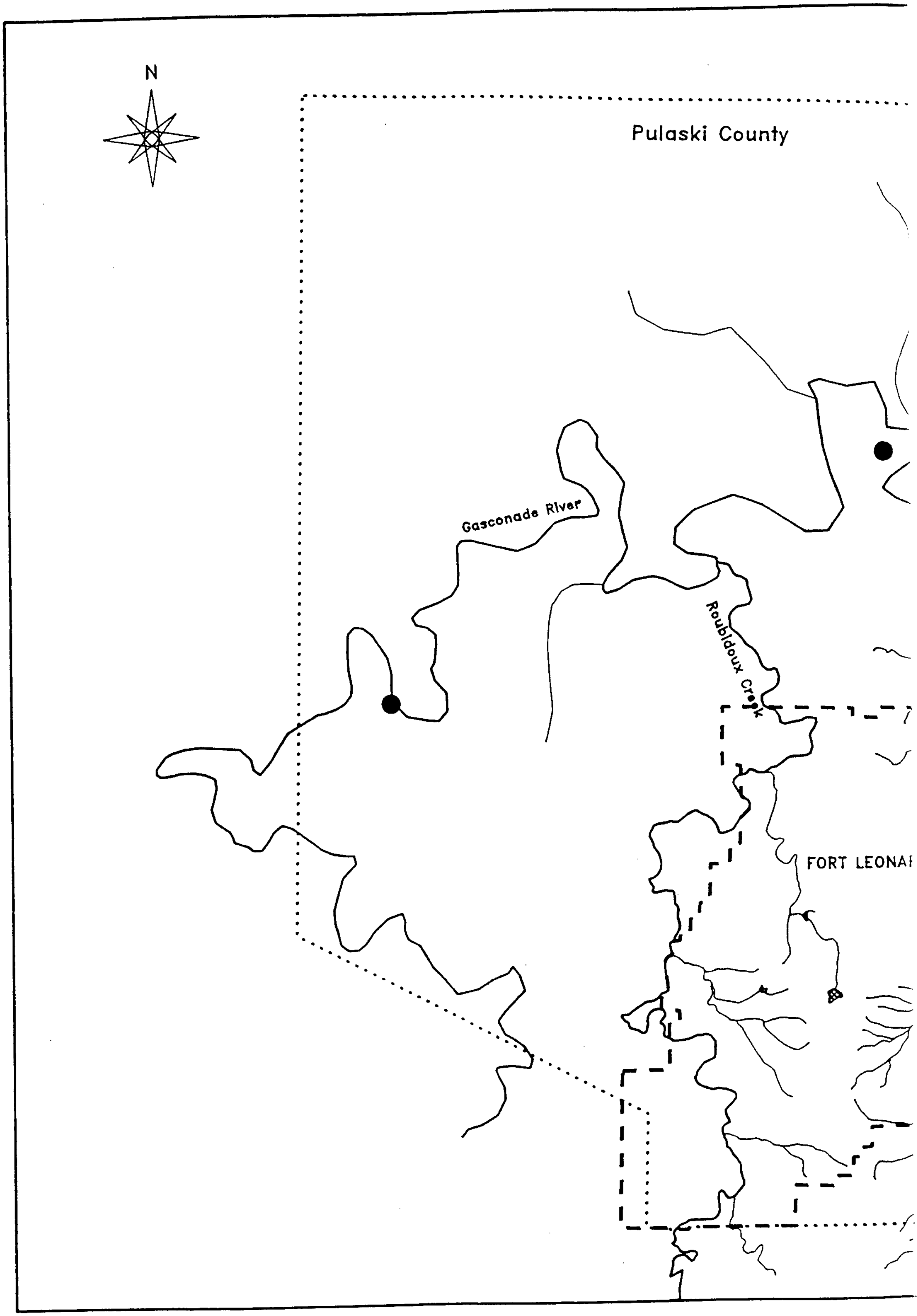
3D/ENVIRONMENTAL

Wintering eagles appear to concentrate in certain areas on Fort Leonard Wood. Three eagle concentration areas (Figure 6-1) were determined based on the sighting of 10 or more eagles within a 2 km stretch of either Roubidoux Creek or Big Piney River between 1988 and 1995. Two of these areas are along Roubidoux Creek, one along an east-west run just north of Cannon Range and the other along a north-south stretch within Cannon Range. The third eagle concentration area is along Big Piney River at the installation's golf course.

For purposes of this analysis, suitable habitat within 400 m of the Roubidoux Creek or Big Piney River constitutes a bald eagle "use area." Roubidoux Creek in the northwestern part of the Installation is unsuitable habitat for wintering bald eagles and is not included in bald eagle use areas. This determination was based on 4 factors:

- There are few potential perch trees along this stretch of stream.
- This portion of Roubidoux Creek freezes in winter.
- Fish collected from this area are small, all less than 5 inches long (T. Glueck, pers. communication).
- No eagles have been observed in this stretch of Roubidoux Creek during winter counts since 1988.

Three recently active nest sites are known from the Gasconade River north of Fort Leonard Wood; however, eagles have not been observed on the Installation during the summer. The nests are 10.4 km, 17.2 km, and 29.6 km (straight-line distance) from Fort Leonard Wood, respectively. One nest site is upstream from the Installation, 38.4 river miles (61.8 km), and two are downstream, 23.6 and 37.2 river miles (38.1 km and 60.1 km) from the boundary of Fort Leonard Wood (Figure 6-2). Nesting bald eagles have not been observed foraging on Fort Leonard Wood.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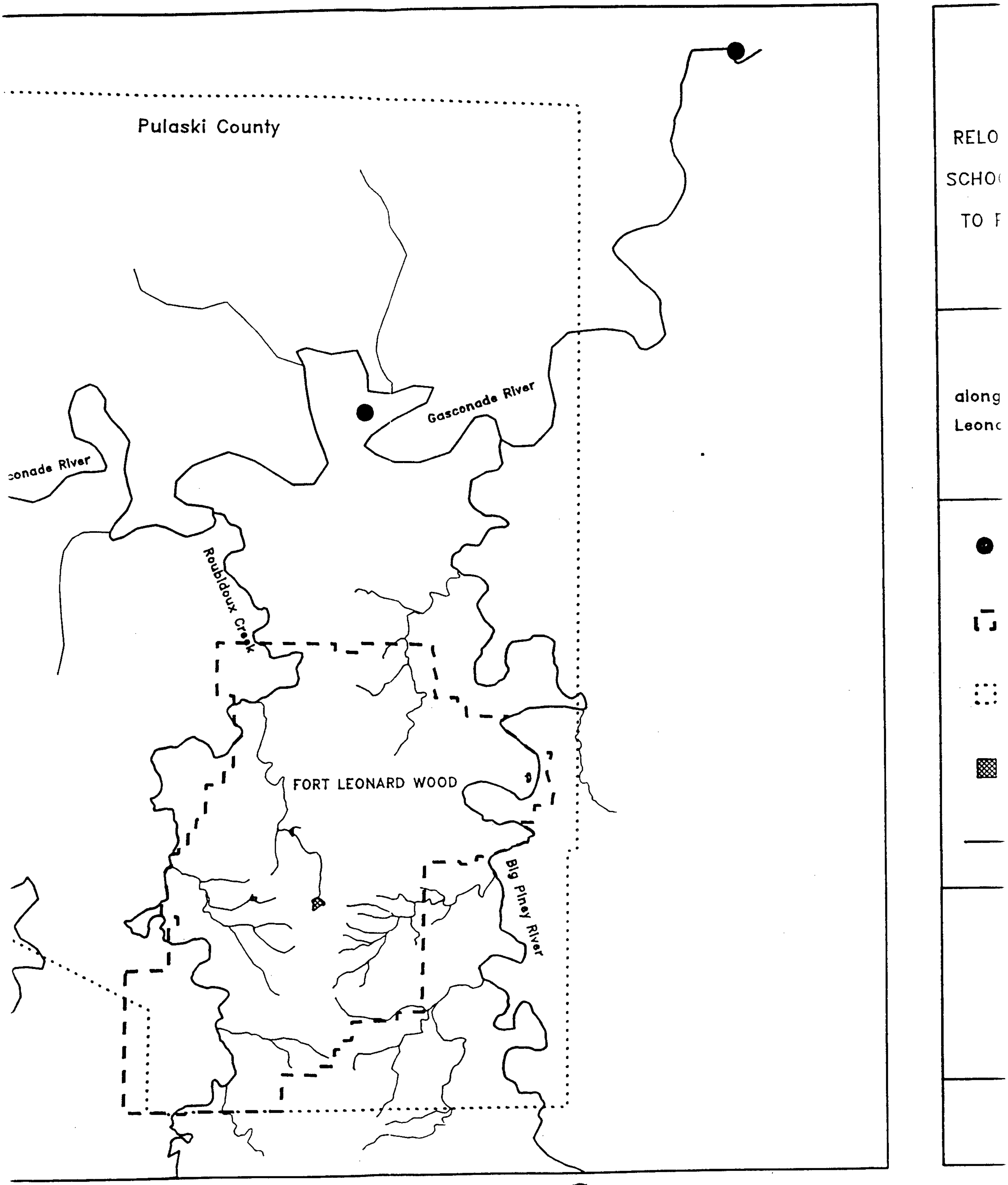
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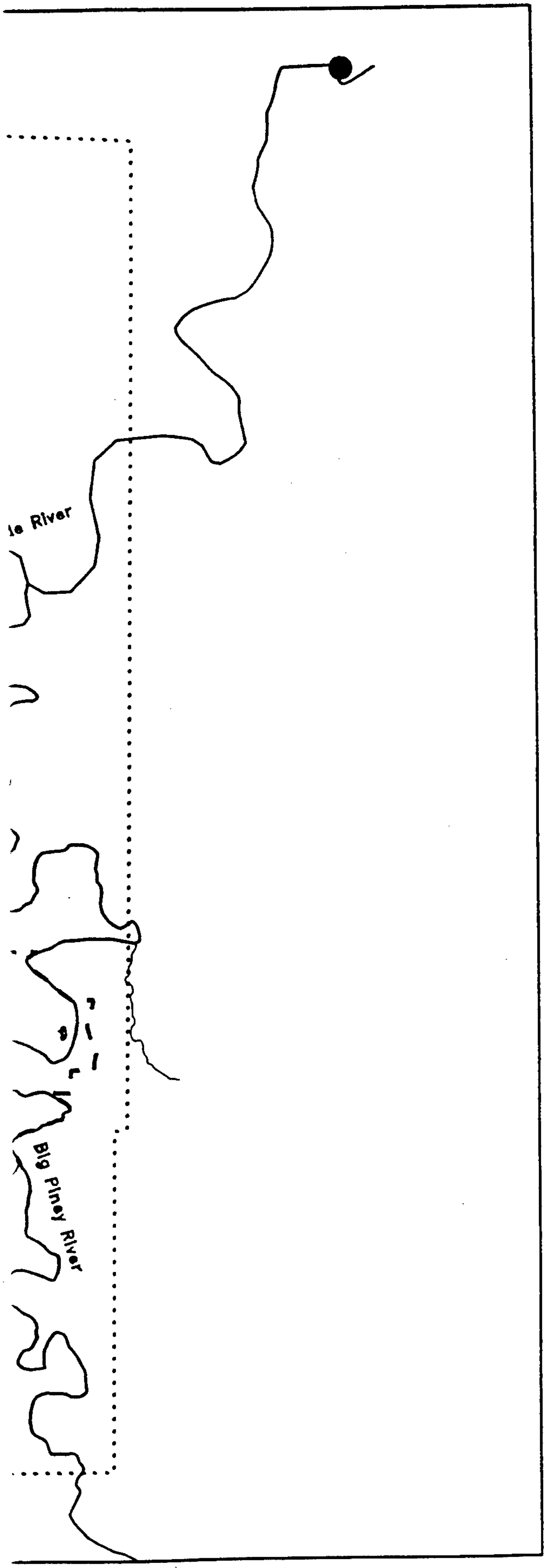


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6-2. Bald eagle nest sites along the Gasconade River near Fort Leonard Wood, Missouri.

- Bald Eagle Nest
- Fort Leonard Wood Boundary
- County Boundary
- Pond
- River / Stream

Kilometers

0 5 10

3D/ENVIRONMENTAL

6.1.2 Scope of Analysis

6.1.2.1 Effect of BRAC-Related Construction to Bald Eagle Habitat

The proposed action includes construction and modification of buildings, training ranges and other support facilities. We assess effects to habitat suitable for wintering bald eagles (Figure 6-3).

6.1.2.2 Effect of Human Presence

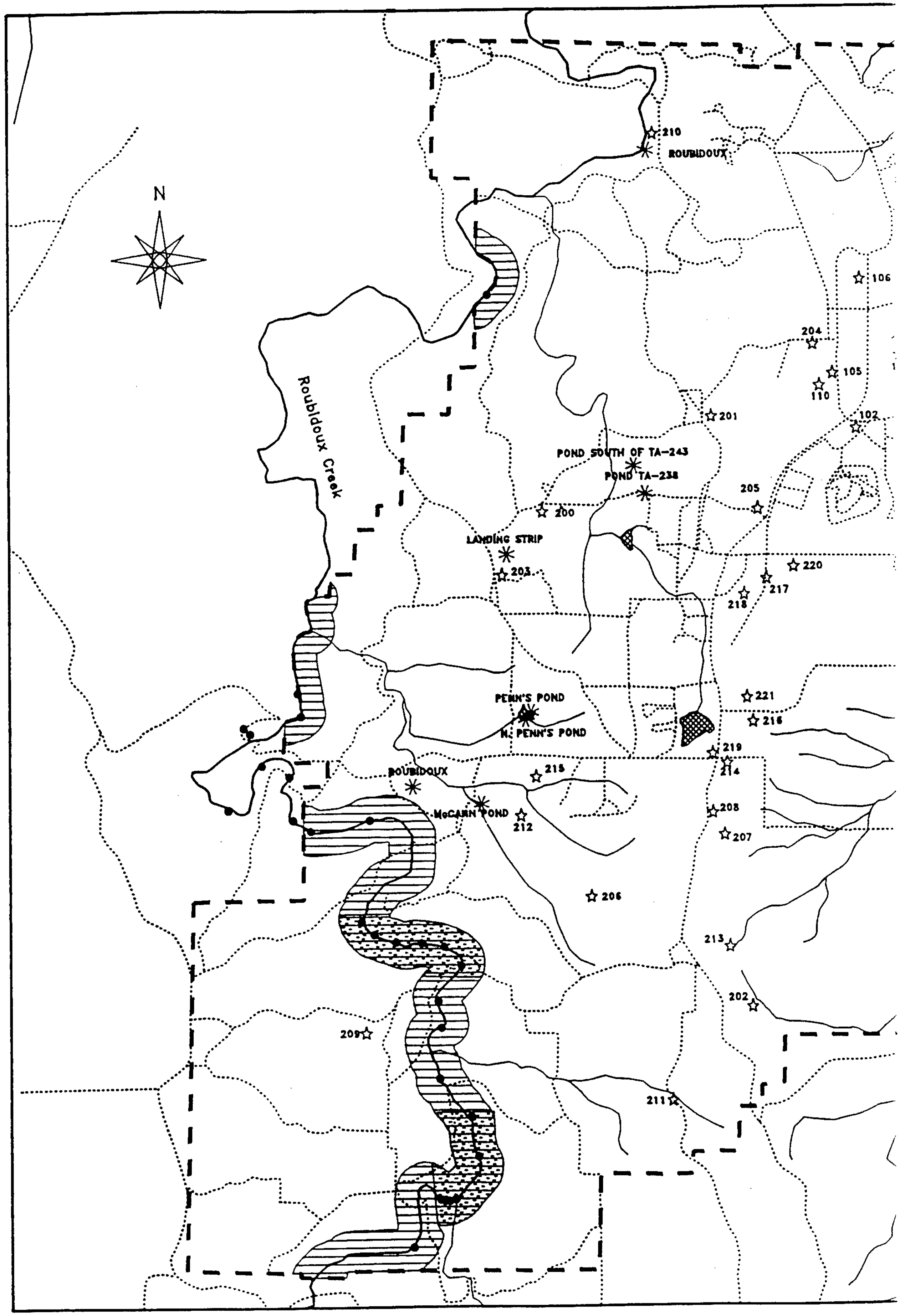
The proposed action includes military training in areas used by wintering bald eagles. We assess effects of disturbance caused by human presence to wintering bald eagles. Impacts of human activity near wintering bald eagles were discussed in the Biological Assessment for the Master Plan and Ongoing Mission (3D/Environmental 1996a) and are incorporated by reference. We concluded human presence within 400 m may affect wintering bald eagles (assuming no screening vegetation). Therefore, any activity where personnel are on foot within bald eagle use areas will disturb perched eagles.

6.1.2.3 Effect of BRAC-Related Sound on Wintering Bald Eagles

Several proposed BRAC training areas and construction projects are near eagle use areas (Figure 6-1) and have potential to disturb bald eagles wintering on the installation. Disturbance to bald eagles could cause eagles to take flight and use critical energy reserves. Disturbed eagles may relocate to less favorable perch locations where they may have greater thermoregulatory energy requirements or decreased foraging efficiency.

3D/Environmental examined potential of proposed BRAC actions at Fort Leonard Wood to disturb wintering bald eagles. The following training activities were examined:

- Maneuver Operations (vehicles, personnel, and other equipment)
- Mines and Obstacles (vehicles, obstacles, and personnel)
- NBC Warning (vehicles, personnel, and decontamination equipment)
- Night-Time Squad Engagement (personnel and small arms)
- BIDS Employment (personnel and vehicles)
- FOX Battlefield Employment and Operation (personnel and vehicles)
- Signals and Other Non-Verbal Communication (personnel, vehicles, and flares)
- Radio Communications (personnel and vehicles)
- NBC Procedures (personnel and vehicles)
- NBC Survival Recovery (personnel and vehicles)



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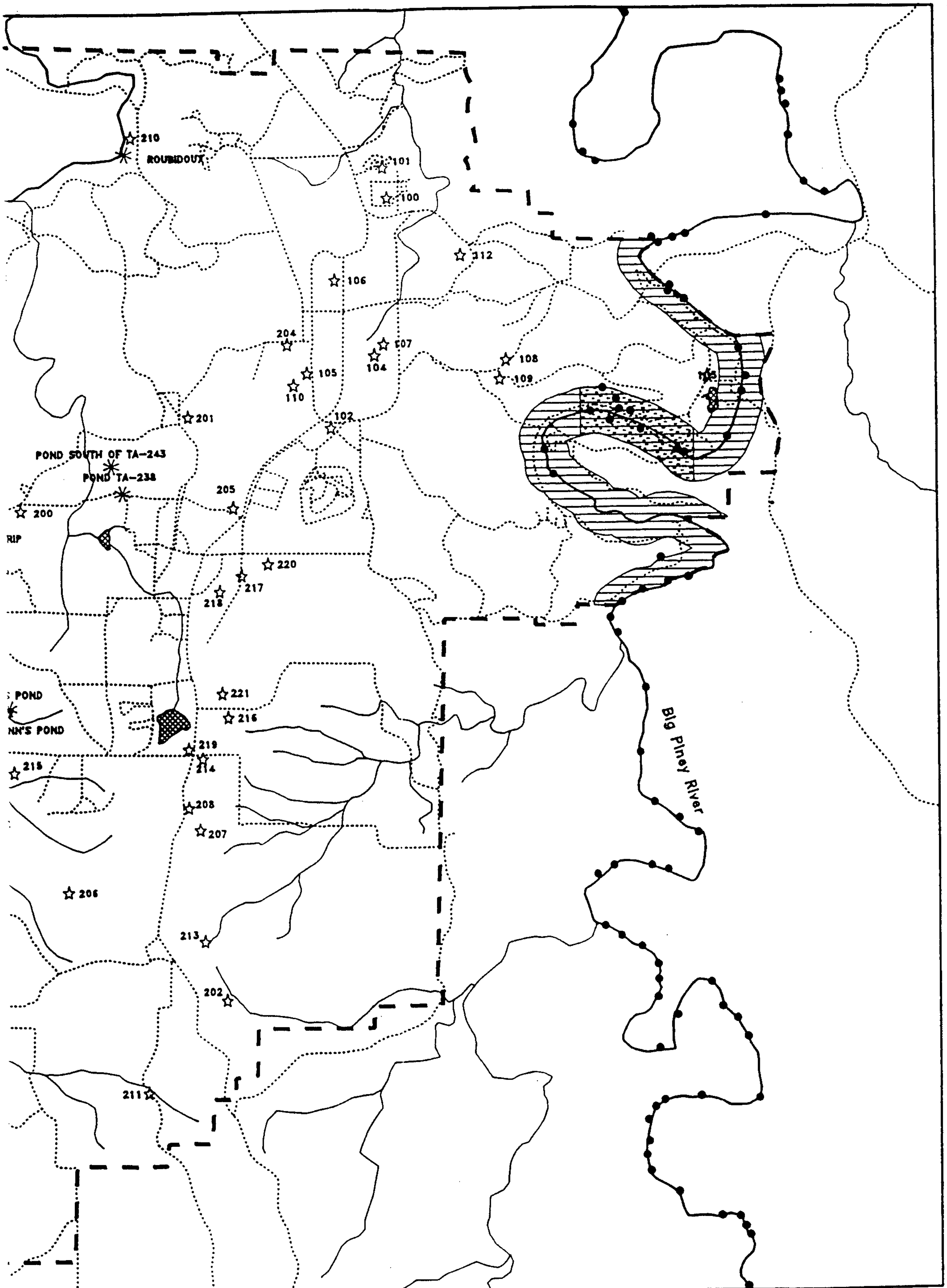

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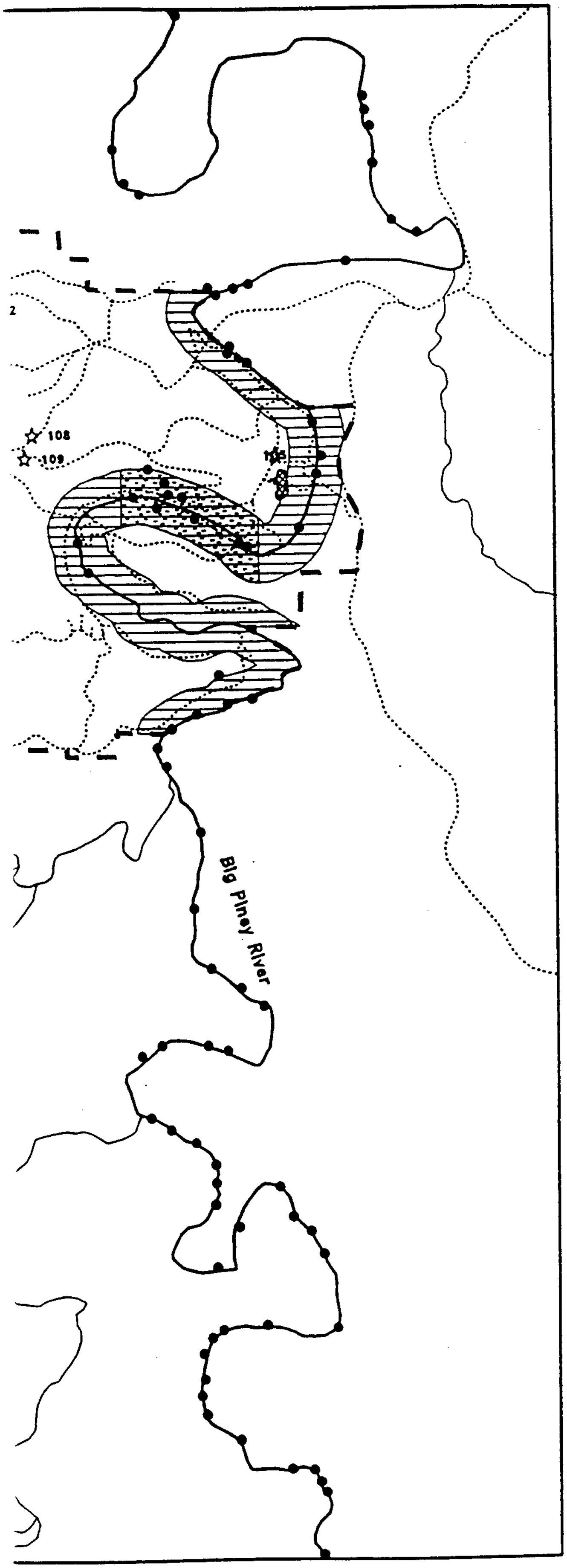


BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6–3. Proposed locations of new facilities and BRAC training, and bald eagle winter occurrences, use areas, and concentration areas on Fort Leonard Wood, Missouri. Numbers refer to project descriptions in Table 4–7.

☆ New Support Facility

✳ Potential Decontamination Site

● Bald Eagle Sighting

Bald Eagle Use Area

Bald Eagle Concentration Area

Fort Leonard Wood Boundary

Road

Pond

River / Stream

Kilometers

0 2 4

3D/ENVIRONMENTAL

- Radiation Safety (personnel and vehicles)
- Vehicle Operations
- Driver Qualifications (vehicles)
- Explosive detonations at Range 10

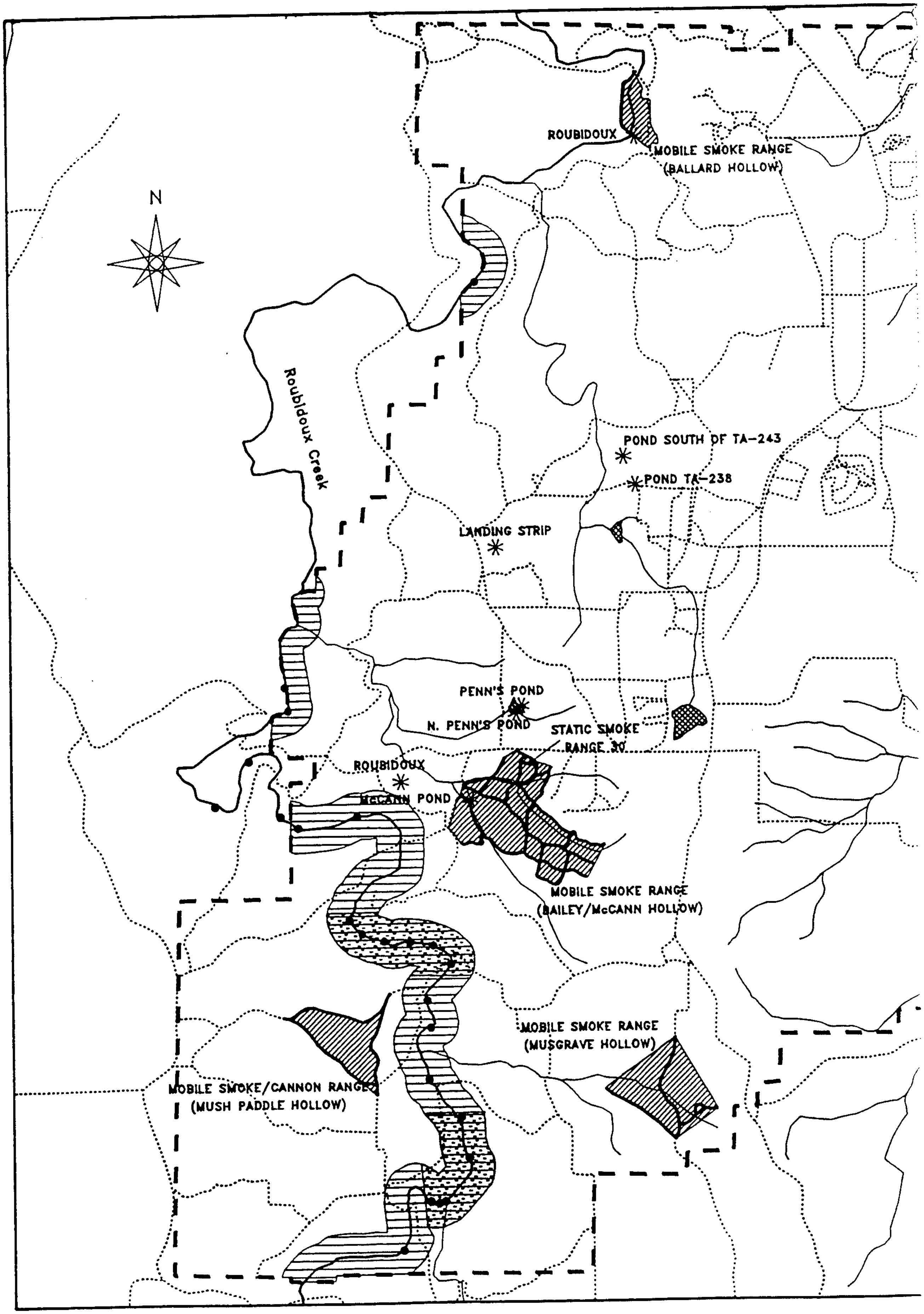
These activities will be located outside eagle use areas and will not impact wintering bald eagles.

BRAC actions at Fort Leonard Wood which have potential to impact wintering bald eagles from sound disturbances are 1) construction activities, 2) decontamination training, and 3) mobile smoke training. We evaluated potential impacts to bald eagles of sound generated by construction, decontamination training, and mobile smoke training (Figure 6-4).

Construction projects associated with the BRAC action will involve use of heavy equipment. Because hearing protection is required by Army personnel operating this equipment, we determined sound was of sufficient intensity to examine sound levels reaching eagle use areas.

Decontamination training (Air Force Base Recovery, NBC Procedures) is conducted at water sources. Training involves decontamination (washing) of vehicles by pumping water through a high pressure washer. Because sound generated by equipment is of sufficient intensity to require personnel to wear hearing protection, decontamination training was examined for potential impacts to wintering bald eagles.

Mobile smoke training areas are large areas where vehicle mounted "smoke generators" produce obscurant fogs (Figure 6-5). Fort Leonard Wood (Emily Brown, January 9, 1996) recommended examination of two configurations of smoke generators for this study: the M56 and M157, both mounted on high mobility multipurpose wheeled vehicles (HMMWVs). The M56 generator uses a turbine engine to vaporize fog oil to provide visual obscurants. The M157 generator uses a pulse jet engine to vaporize fog oil to produce a visual obscurant fog. Because both the M56 and M157 generate sound of sufficient intensity to require personnel to wear hearing protection, smoke generators were examined for potential impacts to wintering bald eagles.



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POND SOUTH OF TA-243
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STATIC SMOKE
RANGE 30
ROUBIDOUX
McCANN POND
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)
MOBILE SMOKE/CANNON RANGE
(MUSH PADDLE HOLLOW)

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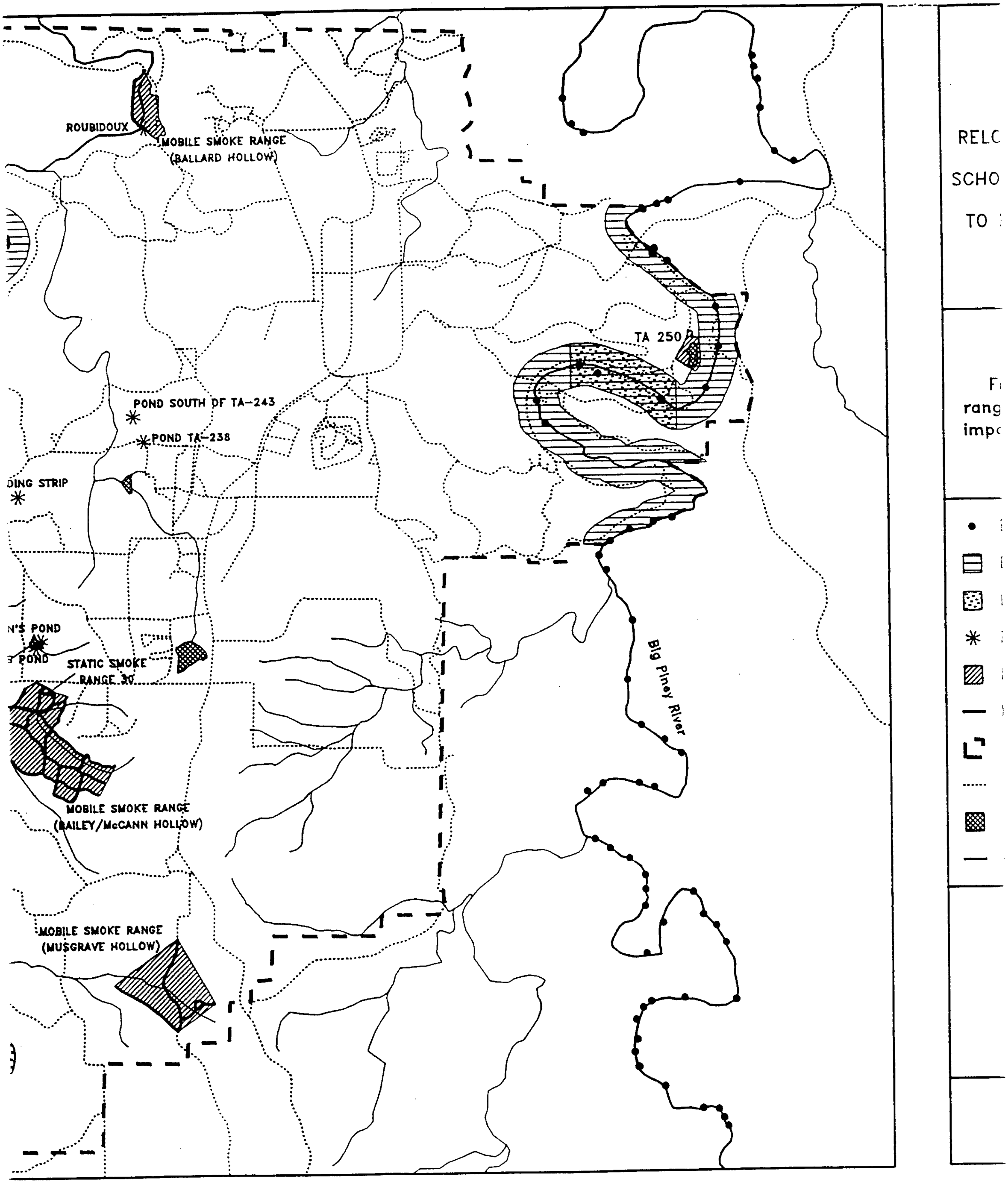
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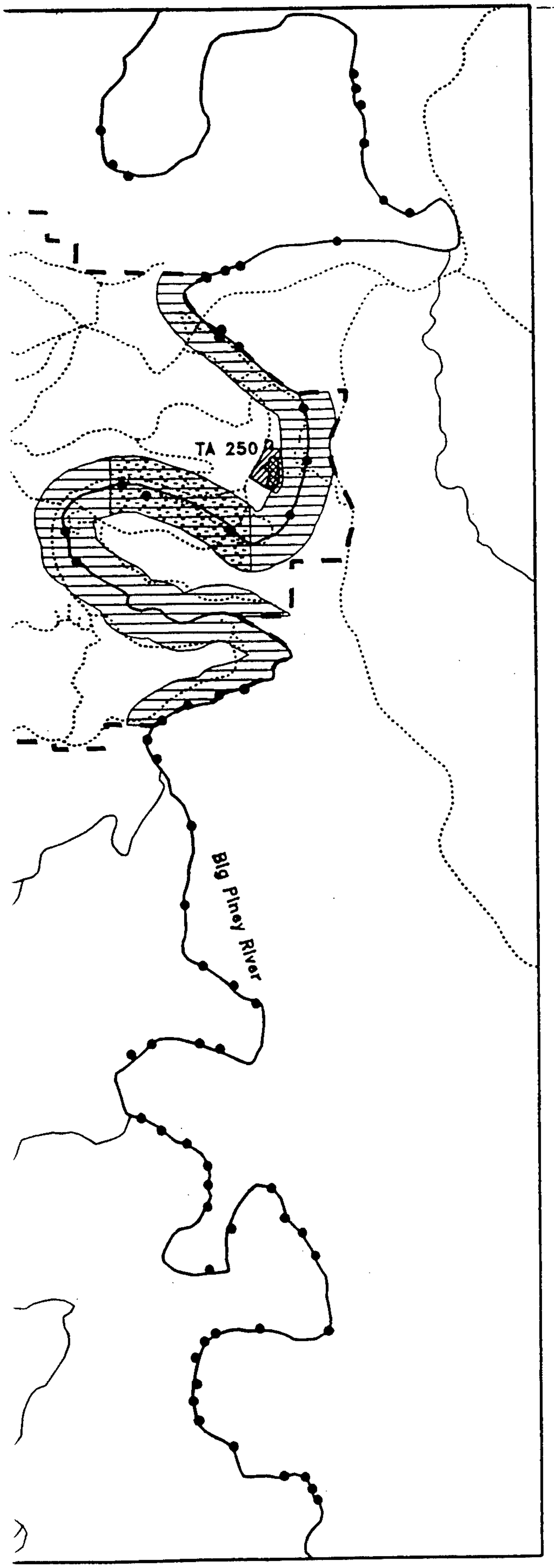

BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6-4. BRAC-related training ranges generating sound potentially impacting wintering bald eagles.

- Bald Eagle Sighting
- Bald Eagle Use Area
- Bald Eagle Concentration Area
- Potential Decontamination Site
- Mobile Smoke Training Area
- Mobile Smoke Deployment Road
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream

Kilometers

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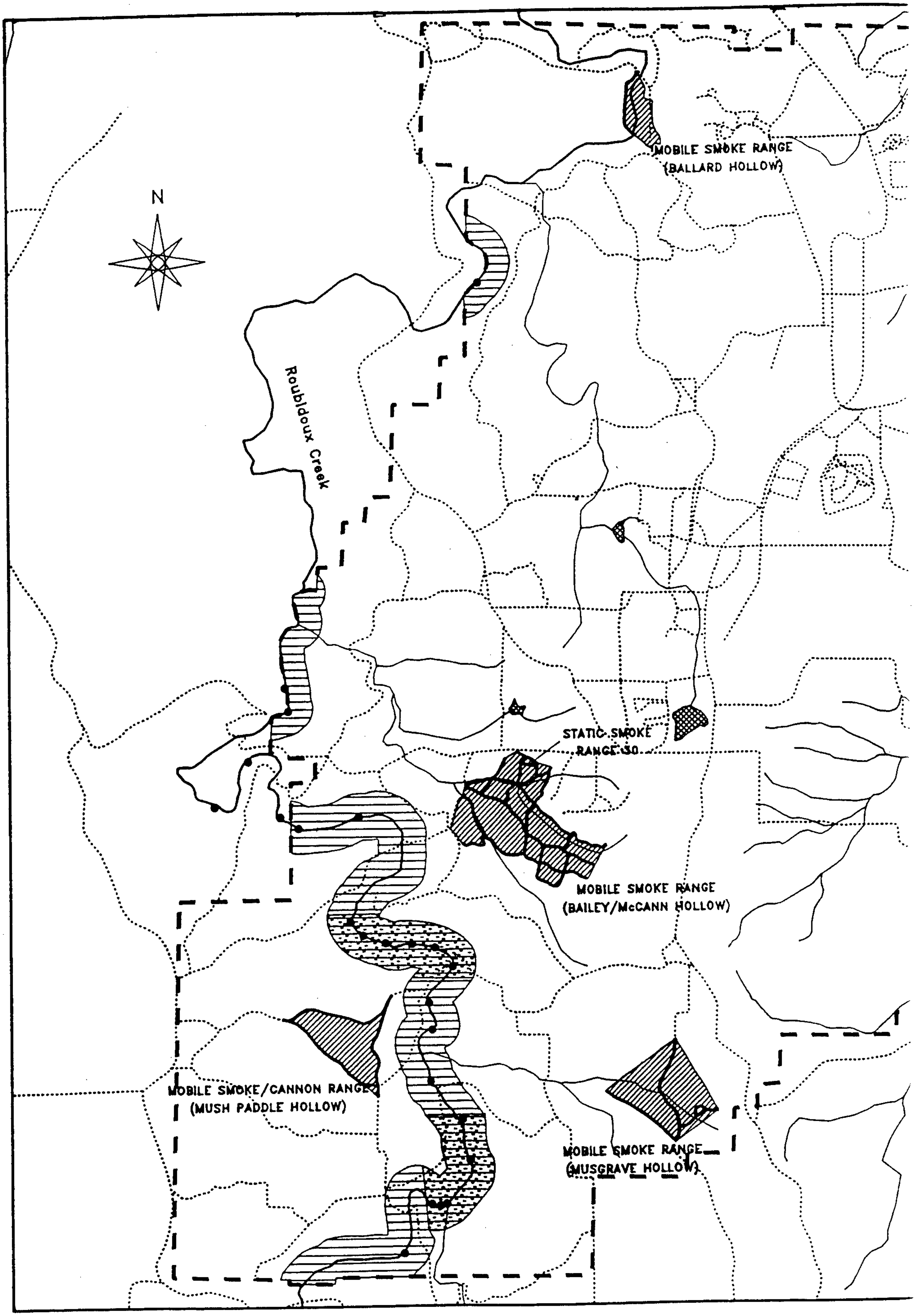
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(MUSH PADDLE HOLLOW)
MOBILE SMOKE RANGE
(MUSGRAVE HOLLOW)

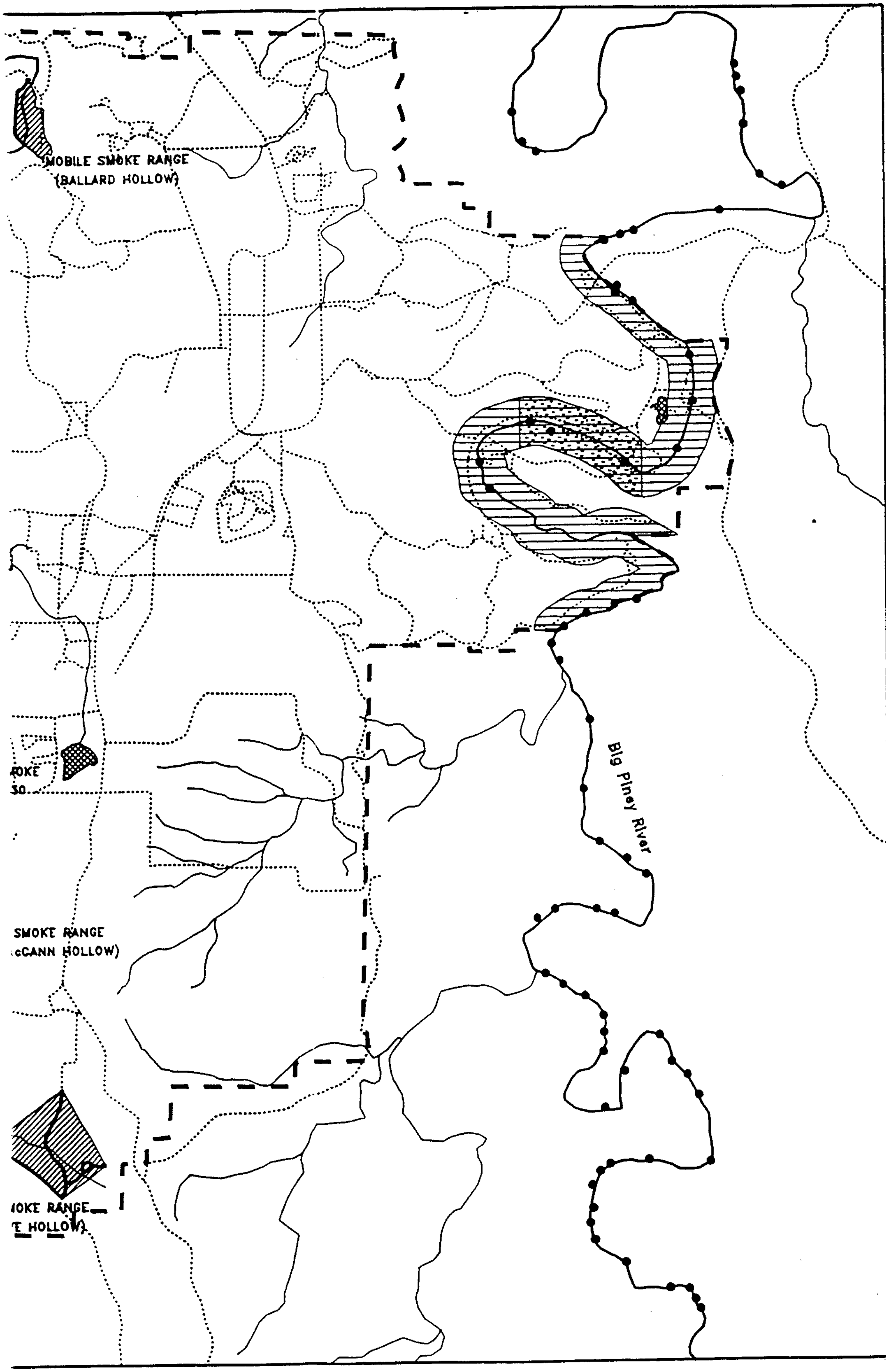

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FIGURE 6-5. B
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- Bald Eagle Si
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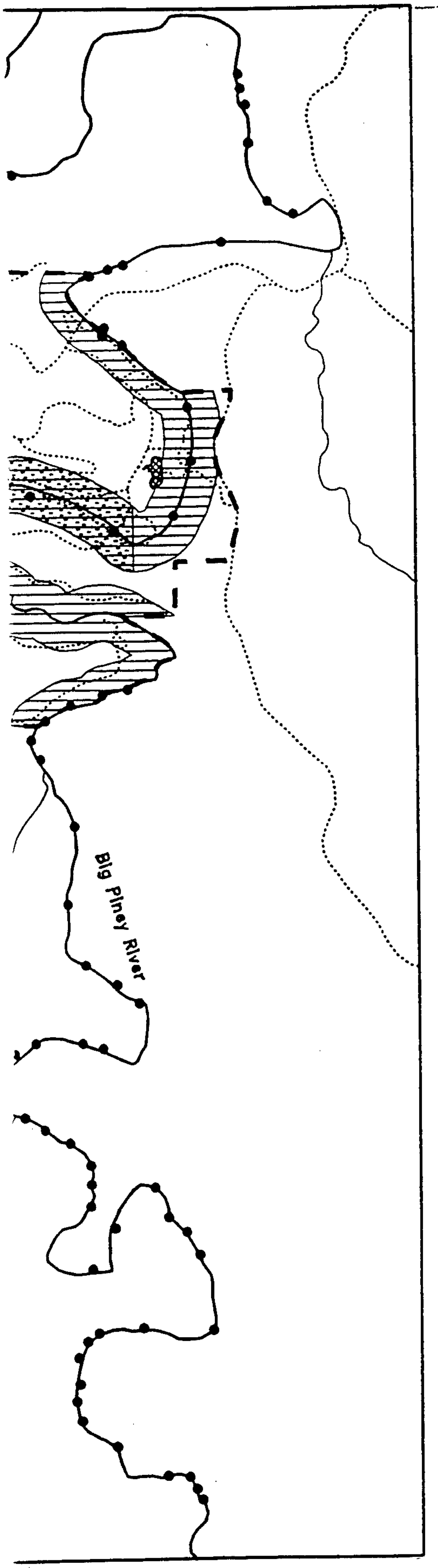


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6–5. Bald eagle winter occurrences, use areas, and concentration areas; and proposed fog oil smoke training areas at Fort Leonard Wood, Missouri.

- Bald Eagle Sighting
- Bald Eagle Use Area
- Bald Eagle Concentration Area
- Mobile Smoke Training Area
- Mobile Smoke Deployment Road
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream

Kilometers
0 2 4

3D/ENVIRONMENTAL

6.1.2.4 Effect of Toxicological Agents

Bald eagles may be exposed to training substances when they fly (travel), perch, or forage. This activity is only expected to occur on the installation during the winter. Eagles may also be exposed at nest sites. Three recently active nests exist along the Gasconade River north of the Installation. 3D/Environmental assessed the potential for toxicological effects from exposure to a variety of training materials (Appendix IV, Attachment A).

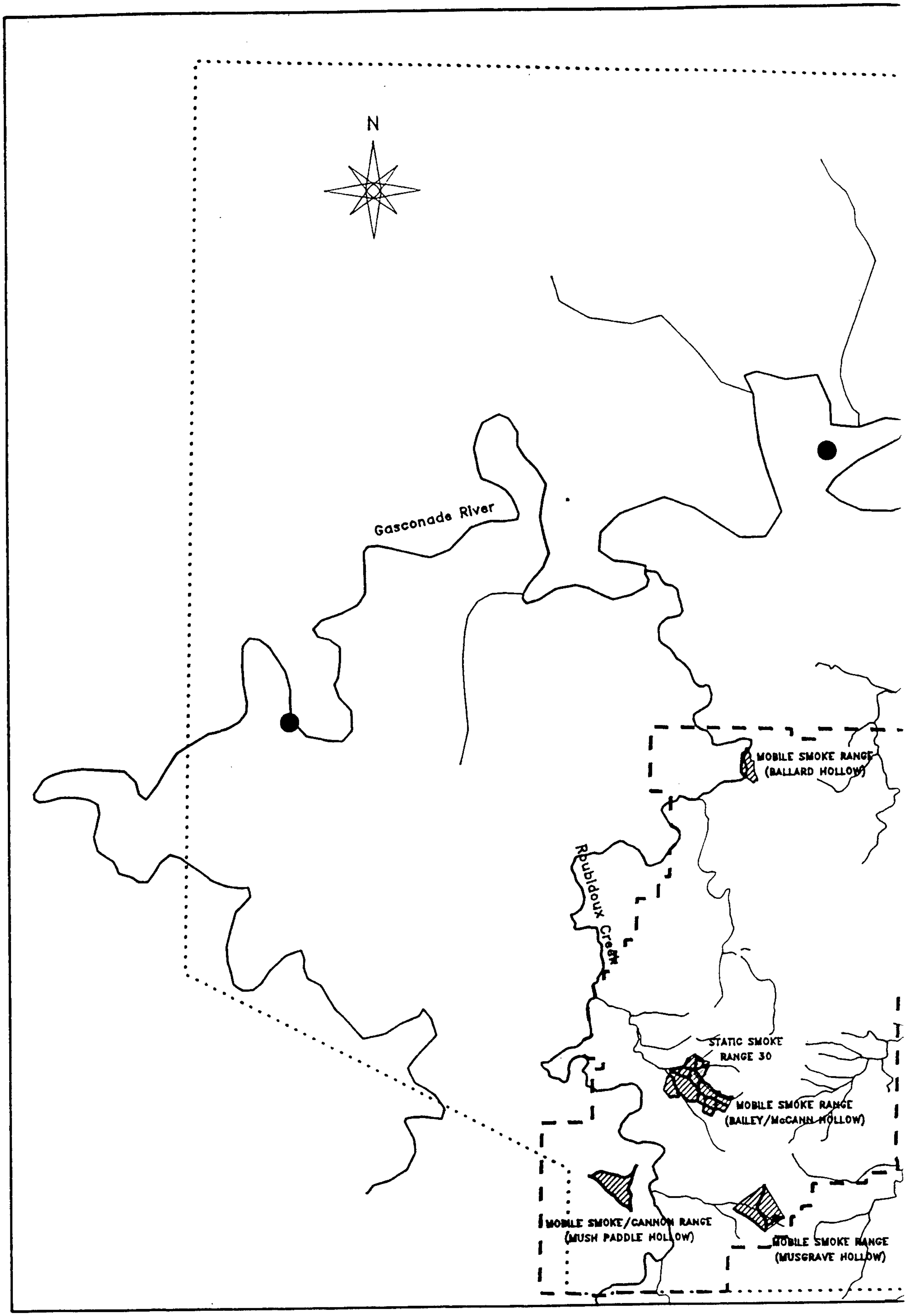
- Certain materials were excluded from detailed analysis in a preliminary screening. Exclusion was based upon an assessment of toxicity, quantity to be used, storage and use location, and method of deployment (Appendix IV, Attachment A).
-
- Certain training materials were assumed to be of limited threat to listed species, and were not evaluated. Potential effects of these substances will be assessed in a biomonitoring plan to be implemented by the Installation (see Section 2.2.4).

- Certain materials were excluded from detailed analysis based upon results of a screening level risk assessment (Appendix IV, Attachment A).

- Remaining training materials were evaluated in detail in an Ecological Risk Assessment (Appendix IV). We evaluated effects of fog oil obscurant (Figures 6-5 and 6-6), terephthalic acid grenades and smoke pots (Figures 6-7 and 6-8), and titanium dioxide grenades (Figures 6-7 and 6-8).

We considered exposure to toxic concentrations of any stressor to be an effect. Maximum concentrations at which stressors are nontoxic were converted to toxicological values or doses (e.g. NOAEL = No Observable Adverse Effects Level) not expected to result in adverse health effects. Because toxicity data were derived from studies of laboratory animals (e.g. rats), uncertainty factors (UF) were applied when deriving toxicity values for receptors. Uncertainty factors account for anatomical, physiological, or morphological differences between species for which the dose was calculated and the species of concern.

Toxicity Reference Values (TRV) were developed by applying uncertainty factors to the doses (TRV = NOAEL/Uncertainty Factors) following Department of Army guidelines (Wentsel et al. 1994) and procedures outlined in Calabrese and Baldwin (1993). TRVs provide conservative estimates for toxicological effects levels where species-specific toxicity data are lacking. For example, most bald eagle TRVs in this BA were derived by reducing toxicity values of selected mammals by a factor of 1600 (1600 is the product of several multiplicative uncertainty factors). The TRV approach is similar to the RfD approach used in human health risk assessments. Most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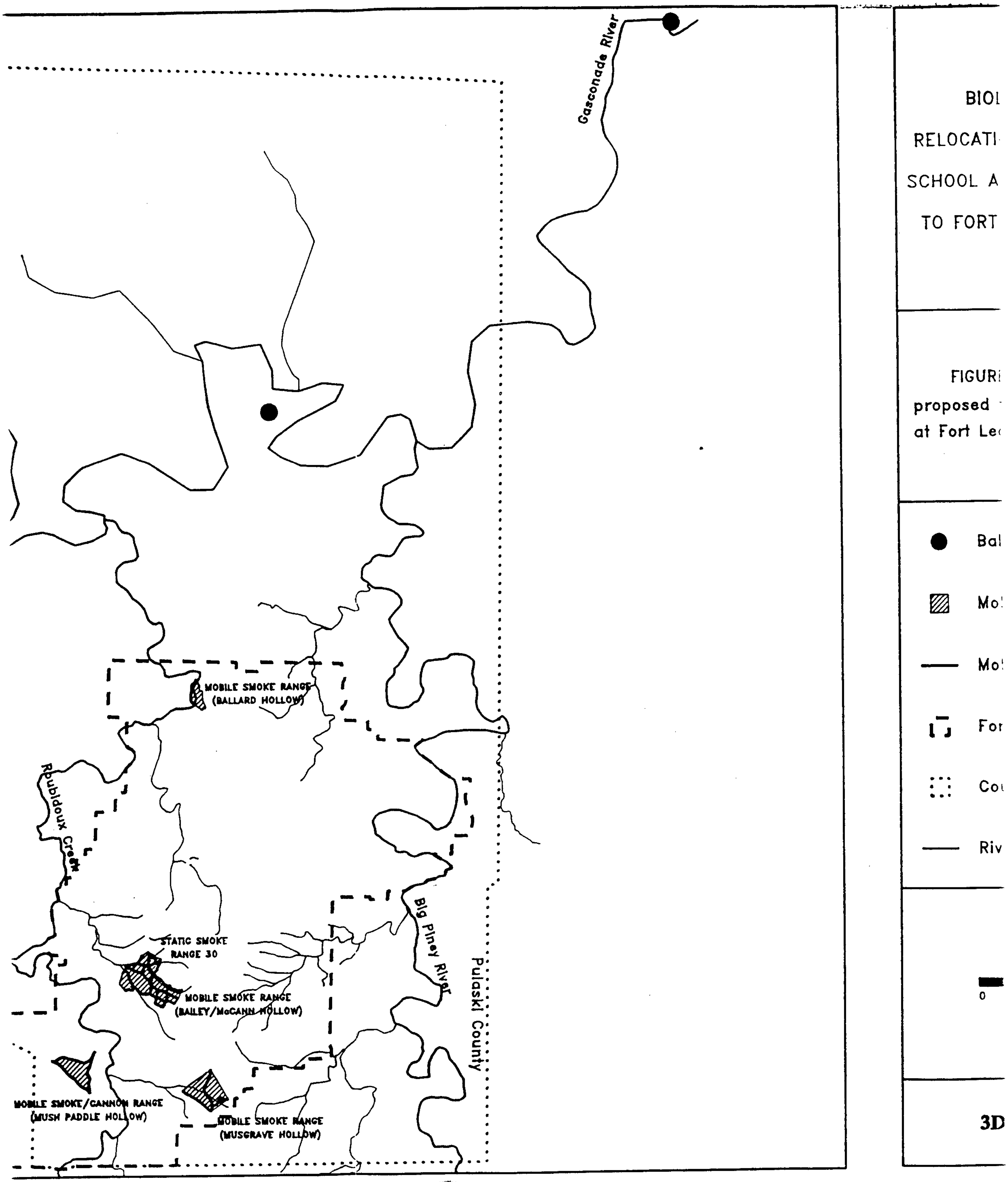

Gasconade River
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(BALLARD HOLLOW)
Roubidoux Creek
STATIC SMOKE
RANGE 30
MOBILE SMOKE RANGE
(BAILEY/McCANN HOLLOW)
Big Piney River
Pulaski County
MOBILE SMOKE/CANNON RANGE
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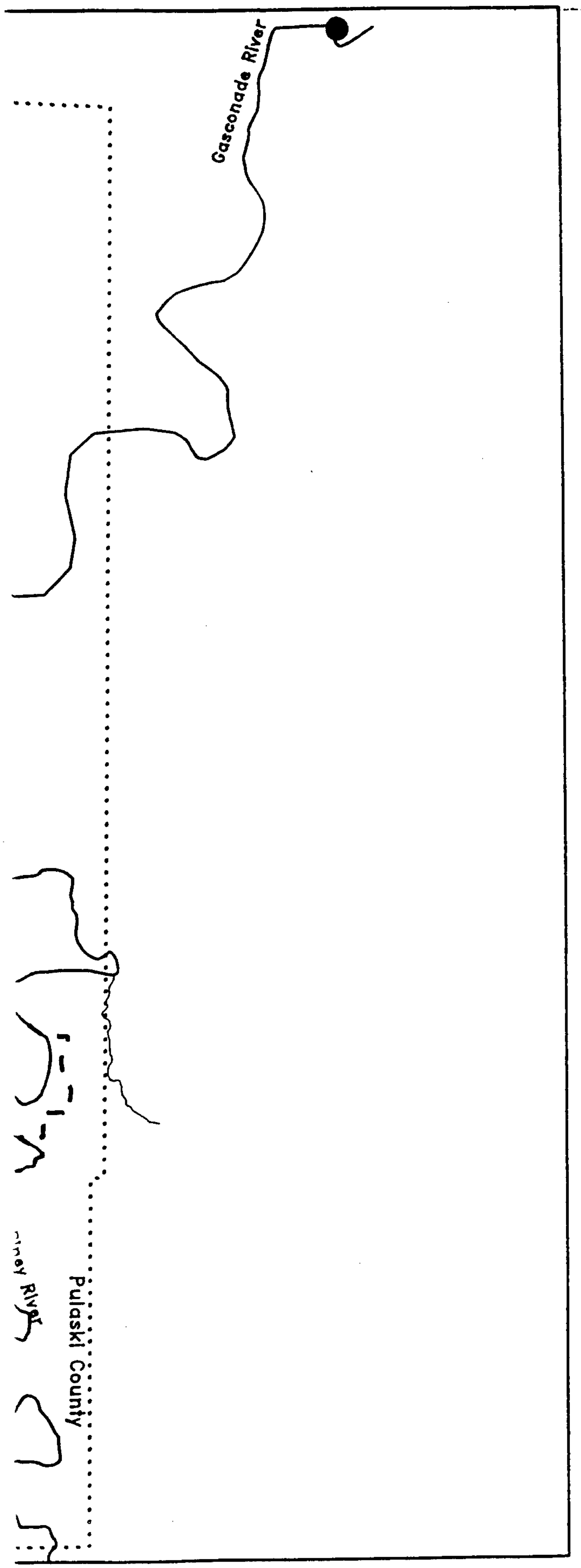


BIOLOGICAL ASSESSMENT:
RELOCATION OF U.S. ARMY CHEMICAL
SCHOOL AND MILITARY POLICE SCHOOL
TO FORT LEONARD WOOD, MISSOURI

FIGURE 6–6. Bald eagle nests and proposed fog oil smoke training locations at Fort Leonard Wood, Missouri.

● Bald Eagle Nest

Mobile Smoke Training Area

Mobile Smoke Deployment Road

Fort Leonard Wood Boundary

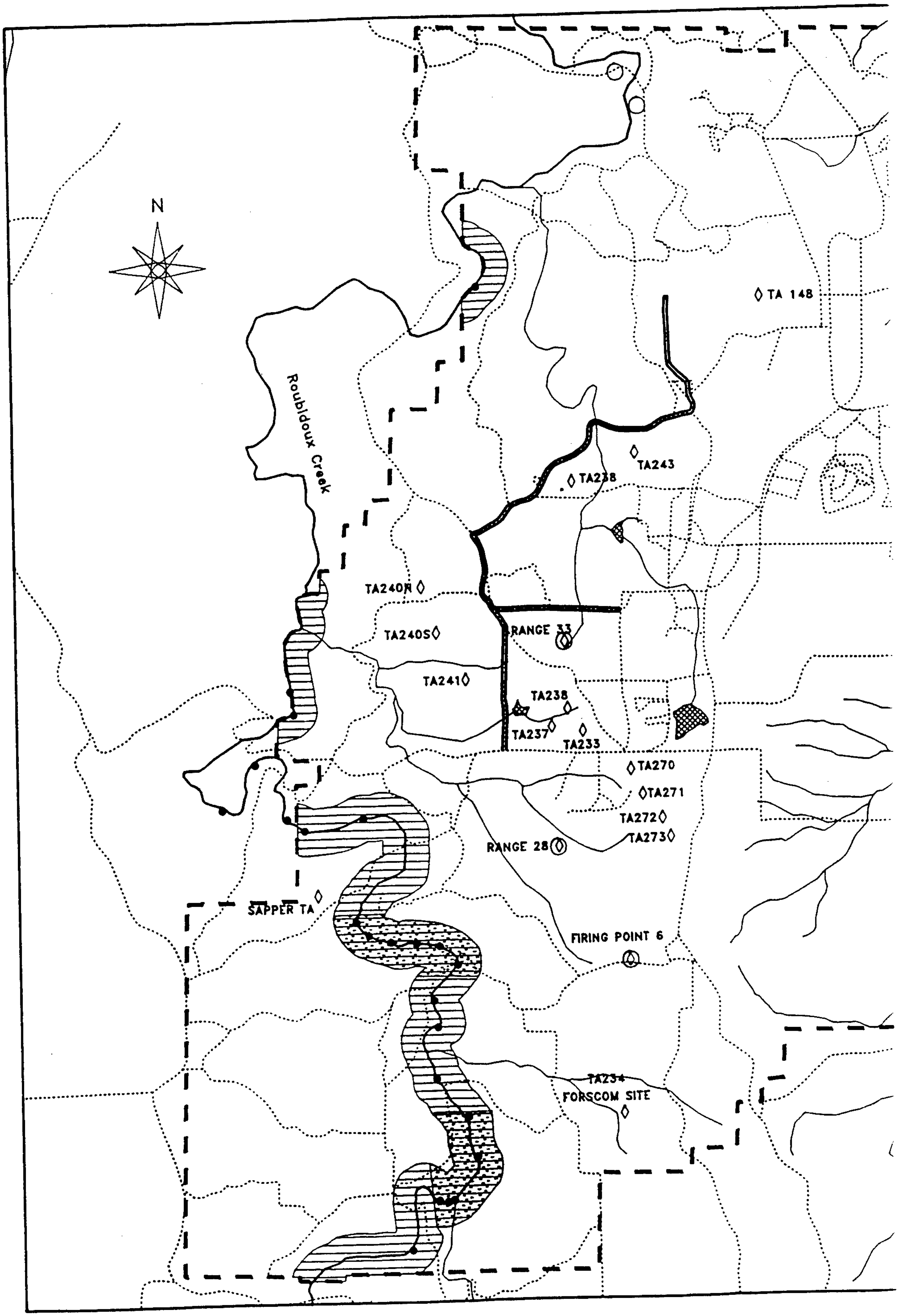
County Boundary

River / Stream

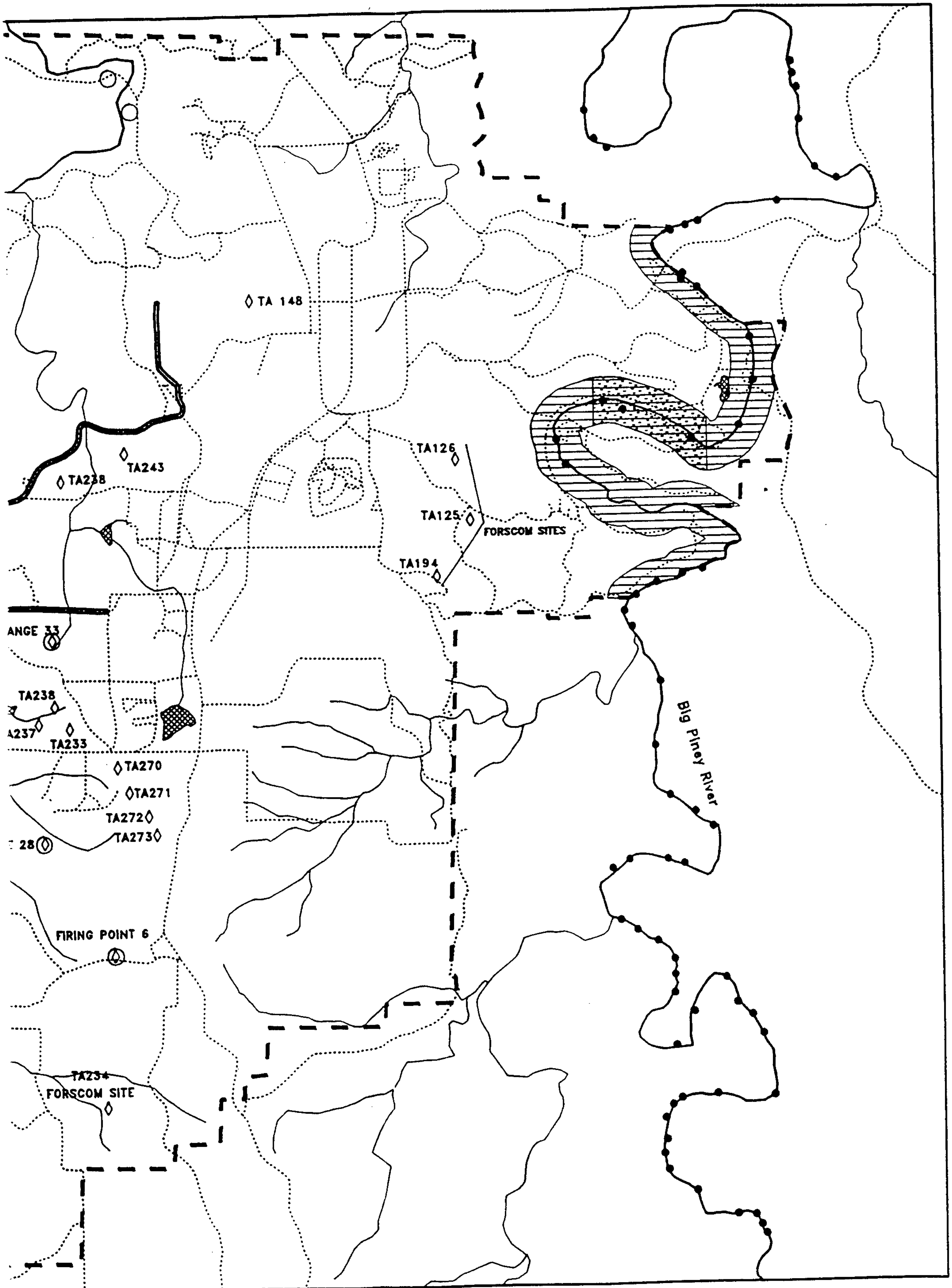
Kilometers

0 5 10

3D/ENVIRONMENTAL


N
Roubidoux Creek
TA 148
TA243
TA238
TA240N
TA240S
RANGE 33
TA241
TA238
TA237
TA233
TA270
TA271
TA272
TA273
RANGE 28
SAPPER TA
FIRING POINT 6
TA234
FORSCOM SITE

1



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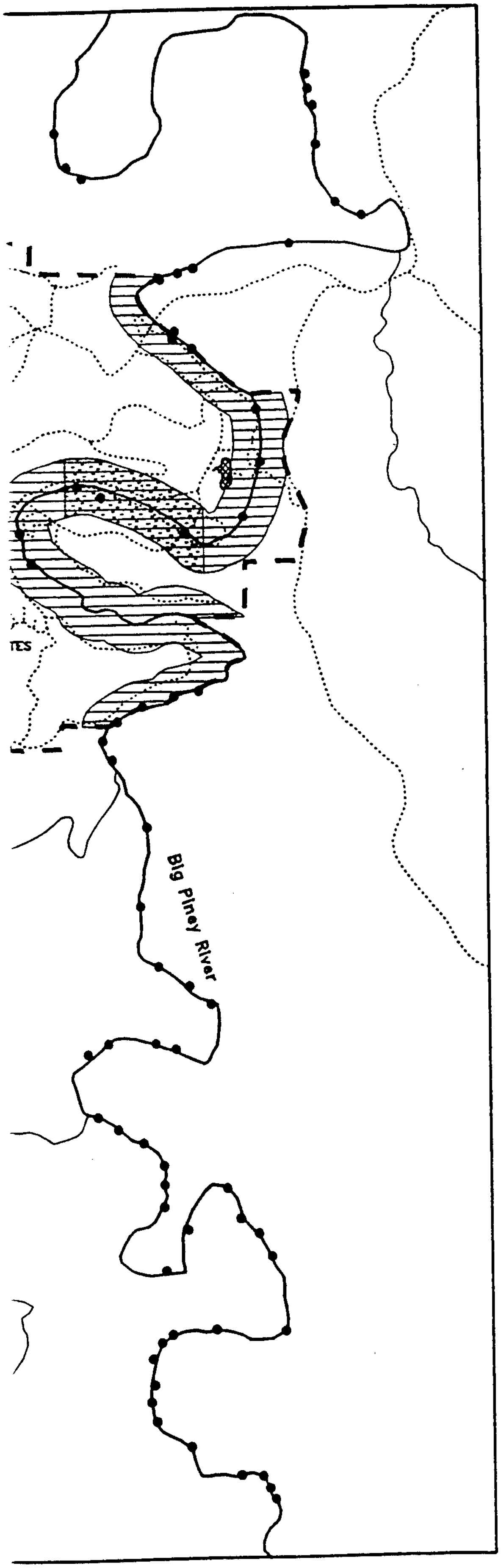
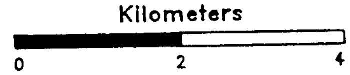


BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6-7. Bald eagle winter occurrences, use areas, and concentration areas; and proposed smoke pot and smoke grenade training locations at Fort Leonard Wood, Missouri. .

- Bald Eagle Sighting
- Bald Eagle Use Area
- Bald Eagle Concentration Area
- Smoke Grenade Use Area
- Smoke Pot Use Area
- Smoke Grenade Training Road
- Fort Leonard Wood Boundary
- Road
- Pond
- River / Stream



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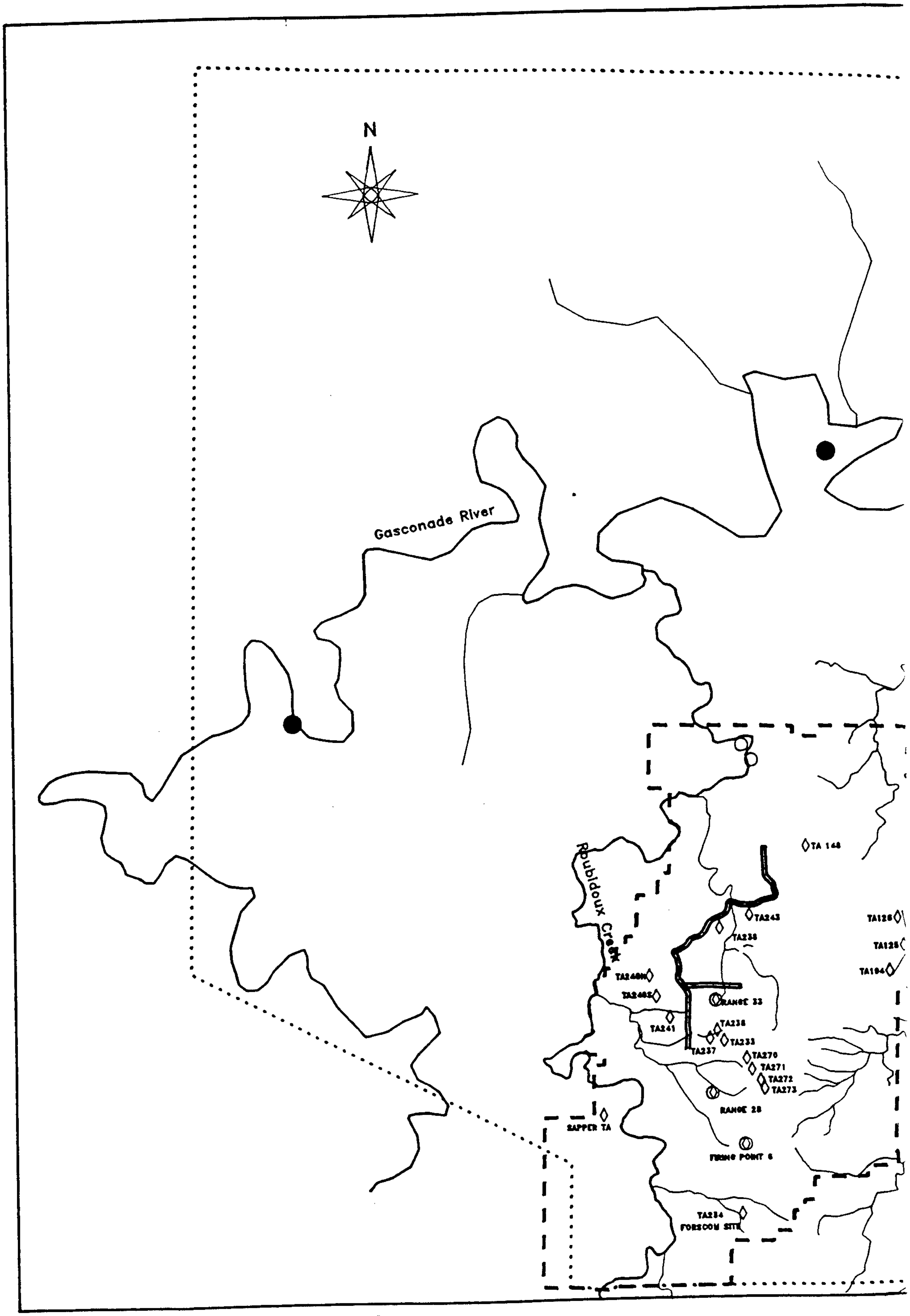
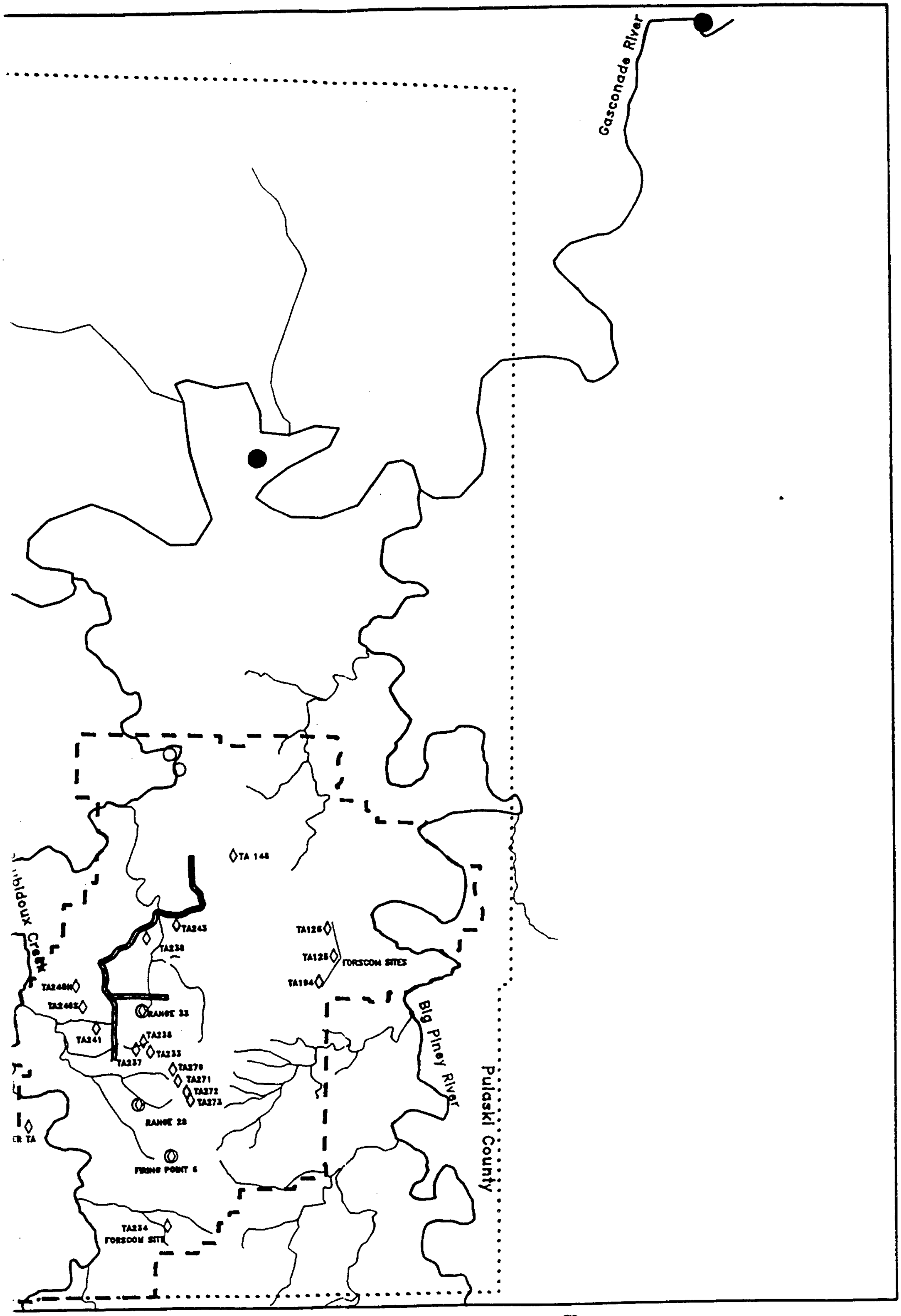


N
Gasconade River
Roubidoux Creek
TA243
TA238
TA125
TA194
TA240N
TA240S
RANGE 33
TA241
TA233
TA237
TA270
TA271
TA272
TA273
RANGE 28
SAPPER TA
TA234
FORSCOM SITE

1



BIOLOGI
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FIGURE 6–
proposed smol
training locatic
Missouri.

● Bald Eaç

◊ Smoke (

○ Smoke F

▬ Smoke (

Fort Leo

County E

— River /

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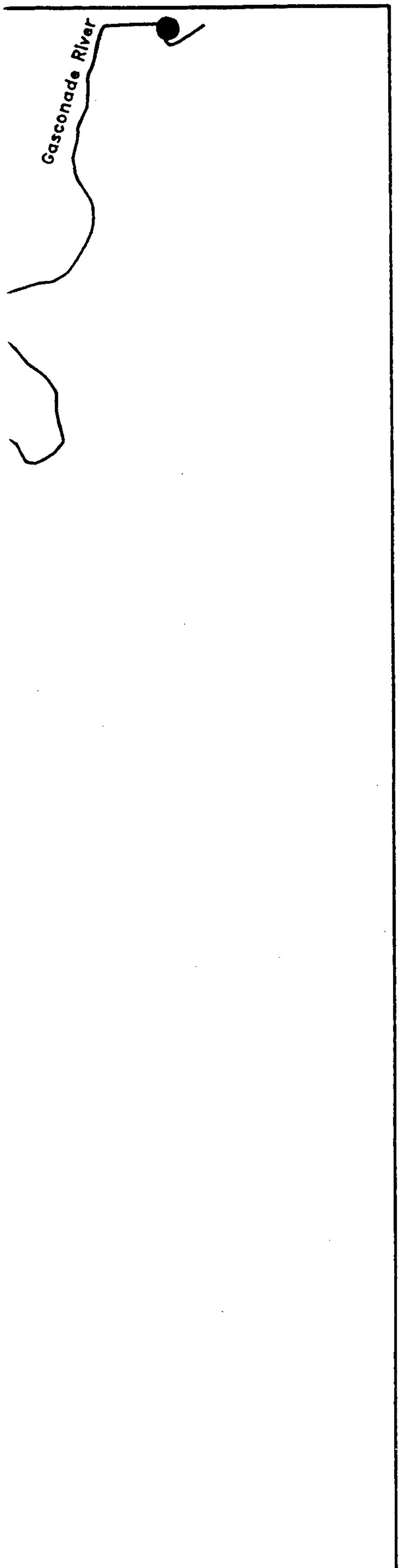
3D/EN



BIOLOGICAL ASSESSMENT:

RELOCATION OF U.S. ARMY CHEMICAL SCHOOL AND MILITARY POLICE SCHOOL TO FORT LEONARD WOOD, MISSOURI

FIGURE 6–8. Bald eagle nests and proposed smoke pot and smoke grenade training locations at Fort Leonard Wood, Missouri.

● Bald Eagle Nest

◊ Smoke Grenade Use Area

○ Smoke Pot Use Area

▬ Smoke Grenade Training Road

Fort Leonard Wood Boundary

County Boundary

— River / Stream

Kilometers

0 5 10

3D/ENVIRONMENTAL

RfDs developed for humans are derived from non-human toxicity values reduced by uncertainty factors ranging from 10 to 10,000.

For fog oil, BIDS simulants, FOX Training simulants, and non-specific simulants, we determined acute and chronic toxicity values available in the literature. We calculated acute and chronic toxicity of TPA using BATS.XLS (3D/Environmental 1996a).Toxicological effects exhibited by test species from which TRVs were derived may or may not adequately characterize effects likely to be manifested in receptors we evaluate here.

Common test species, such as rats, mice, and guinea pigs may demonstrate different effects than can be expected in eagles. "Critical Effects" listed in Appendix IV, Attachments G are effects manifested by test species, not bald eagles. Where we predict receptors will be exposed to unsafe concentrations, we do not necessarily expect Critical Effects will result. We list Critical Effects as a reference only. Inferences from Critical Effects must be made with caution. Our description of specific effects likely to be manifested by bald eagles is limited by available toxicity data.

Development of acute and chronic toxicity values for the receptors in this analysis is beyond the scope of this Biological Assessment. These tests, if completed for the numerous potential contaminants evaluated, are expensive, time consuming. It is common practice to extrapolate toxicity values from test species to the species of interest.

Section 4.1.2.3 of this BA provides general background information on each of the stressors to be evaluated in detail, and describes the magnitude of proposed stressor use.

We assumed contaminants reach watercourses, and assessed indirect effects. We believe fog oil will not cause indirect effects. 3D/Environmental (1996c) evaluated the environmental fate of fog oil at Fort McClellan, Alabama. No increase of fog oil hydrocarbons were noted in soil, surface water, sediment, tree bark, leaf, insect, or bat tissue samples taken from fog oil exposure sites. Fog oil is biodegradable and will remain in soil only a few days, depending on soil fauna present and time of year the fog oil is released.

Harmful quantities of fog oil are not expected to accumulate in the environment at Fort Leonard Wood because fog oil is readily biodegraded by aerobic microorganisms. Large quantities of fog oil will not reach caves, groundwater, or other water systems via soil erosion,

deposition, or storm water runoff. When fog oil enters water, it is rapidly attenuated due to its water solubility. Fog oil is biodegraded by microorganisms, and undergoes chemical degradation in aqueous environments. We do not anticipate accumulation of fog oil or its components in soil, groundwater, or surface water at Fort Leonard Wood. Prey species are unlikely to be affected by exposure to fog oil through aquatic pathways.

Prey species are unlikely to be affected by exposure to TPA through aquatic pathways. The primary combustion products of TPA are carbon monoxide, carbon dioxide, sulfur dioxide, benzene, toluene, and formaldehyde. These compounds are released in a gaseous state. It is very unlikely they will accumulate in soil or water because they volatilize and are transformed by photochemical reactions. If small quantities enter groundwater or surface water systems, they will be biodegraded by microorganisms. The particulate matter of TPA may be removed from the atmosphere by dry or wet deposition. TPA is relatively insoluble in water, but certain combustion products may enter water systems. Quantities that enter water systems (i.e. groundwater or surface water) will be rapidly degraded through photochemical reactions or through biodegradation. TPA is an organic acid that many terrestrial and aquatic microorganisms can use in their metabolic processes.

6.1.3 Life History

A detailed summary of winter habitat requirements for this species, is contained in Section 6.1.2 of the Biological Assessment for the Master Plan and Ongoing Mission (3D/Environmental 1996a).

Bald eagle nest sites typically are within 2 miles of open water and most are within 0.5 mile (various authors compiled in Green 1985). The primary food resources for bald eagles are fish, waterfowl, and seabirds. Bald eagles build nests in dominant or co-dominant trees. Nesting in snags is atypical, with most nests in living trees with stout horizontal limbs. Nests are located in the top third of trees. The trees typically have overhanging branches sheltering the nest (Green 1985).

The reproduction period of bald eagles varies with latitude. In Missouri, the onset of nesting behavior can be expected from January through early March (Green 1985). Nesting is not synchronized among sympatric eagles. The time period from the beginning of egg laying

through juvenile independence can range from 164 - 214 days (Green 1985). Nesting eagles may be present in the area surrounding Fort Leonard Wood for much of the year.

Nesting bald eagle home range sizes have been reported to average 57 acres in Alaska and 321 acres along the Columbia River, Washington (McGarigal et al. 1991, Snow 1973). Maximum home range sizes reported have been 111 acres in Alaska and 1038 acres along the Columbia River. McGarigal et al. (1991) report nesting eagles concentrate activity in high productivity foraging areas that comprise only 6% of the total area. Steidl (1994) reported nesting bald eagles in the Gulkana Basin of Alaska spend most of their time within 200 m of the nest. Nesting eagles have a substantial energetic investment in their offspring, and they remain near the nest to protect the young (Steidl and Anthony 1996). If bald eagles summering near the Gasconade River had home ranges of 5190 acres, five times greater than the maximum reported size, their home ranges would not reach Fort Leonard Wood. Because it is unlikely eagles nesting along the Gasconade River utilize Fort Leonard Wood, this Biological Assessment does not include effects to habitat suitable for nesting eagles.

6.1.4 Management Guidelines

A description of existing management guidelines for wintering bald eagles is contained in Section 6.1.3 of the Biological Assessment for the Master Plan and Ongoing Mission (3D/Environmental 1996a). These guidelines are incorporated by reference to limit redundancy.

Relevant management guidelines for nesting bald eagles are contained in the *Northern States Bald Eagle Recovery Plan* (FWS 1983). Guidelines pertaining to wintering eagles are pertinent to this analysis. The recovery plan suggests restricting human activity in areas where eagles are known to forage, maintaining suitable perch trees near foraging areas, and maintaining the quality of foraging habitat.

6.2 EFFECTS ANALYSIS AREA

We assessed effects to wintering bald eagle habitat within the Fort Leonard Wood boundary. We also assessed effects of chemical stressors to wintering bald eagles on Fort Leonard Wood and summering bald eagles near the Installation on the Gasconade River.

6.3 AFFECTED HABITAT DESCRIPTION

A detailed description of the physical environment on the Installation, including topography, physiology, climate, geology, seismicity, soils, air quality, water resources, and vegetation is contained in Section 4 of the EIS for Relocation of the Army Chemical School and Military Police School to Fort Leonard Wood (HBA 1996). The description of these resources is incorporated by reference to limit redundancy.

A description of Big Piney River and Roubidoux Creek is contained in Section 6.3 of the Biological Assessment for the Master Plan and Ongoing Mission at Fort Leonard Wood, Missouri (3D/Environmental 1996a). These habitat descriptions are incorporated by reference.

6.4 STUDY METHODS

6.4.1 Effect of BRAC-Related Construction to Bald Eagle Habitat

We assessed the location of proposed construction and areas where bald eagles are known to occur. We also considered impacts to wooded habitat within 400 m of Roubidoux Creek and Big Piney River. We assumed winter use of the Installation by bald eagles would be concentrated in these areas. The entire length of these two streams within the installation were examined, but adverse effects were limited to those areas with suitable habitat for bald eagle use.

6.4.2 Effect of Human Presence

We assessed the location of proposed training activities and areas where bald eagles are known to occur. We focused upon activities within 400 m of the Roubidoux Creek and Big Piney River. Proposed BRAC training activities that occur within 400 m of these streams also were assessed. We assumed winter use of the Installation by bald eagles would be concentrated in these areas. The entire length of these two streams within the installation were examined, but adverse effects were limited to those areas with suitable habitat for bald eagle use.

6.4.3 Effect of BRAC-Related Sound on Wintering Bald Eagles

We examined locations, sound characteristics, activity of personnel (i.e., human presence), and equipment for construction and training activities near bald eagle use areas. Sound propagation from proposed mobile smoke training areas, decontamination equipment, and

construction activities was modeled to predict approximate levels reaching eagle use areas. Methods for measuring, characterizing, and modeling sound were described in Sections 4.4.5.1, 4.4.5.2, and 4.4.5.4 of Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). These methods are incorporated by reference. Sounds produced by mobile smoke generators (M56 and M157) were measured at Edgewood Area, Aberdeen Proving Ground, Maryland. Measurements were made on single generators. Decontamination equipment was measured at Fort McClellan, Alabama. Sound generated by operation of construction engineers equipment (TA 244) was assumed to represent sound sources generated by BRAC-related construction projects.

We modeled sound propagation from selected training activities to determine approximate sound pressure levels (SPLs) in decibels (dB) reaching eagle use areas. Sound propagation was modeled under different weather conditions using combined sound levels for those activities with multiple sources. For example, mobile smoke training areas operate several smoke generators simultaneously. Sound levels are increased when more than one smoke generator is running, however the sound from two generators is not "twice as loud" as one generator (i.e., the relationship is not strictly additive). For mobile smoke training areas, we assumed 12 generators running simultaneously. Because measurements were made on single generators, we used standard methods for addition of sound levels (Harris 1991) to determine at-source overall sound pressure levels for 12 generators.

Factors disturbing wintering bald eagles were discussed in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a). Sound levels that cause disturbance to wintering eagles were not identified in that review of literature. The literature review conducted for this study focused on recent literature and potential sound disturbances to winter roosting raptors. Impact assessment was based on modeled sound levels reaching eagle use areas, available literature, and guidelines in the Northern States Bald Eagle Recovery Plan (FWS 1983). In the absence of documented guidance, sound generated by construction or training outside eagle use areas was considered to impact wintering bald eagles if it was determined to increase sound levels in eagle use areas by 10 dB or greater. This level was chosen because increases in background sound of 10 dB (A-weighted) are considered "substantial" in highway noise analyses (FHWA 1995, Samis and Hamilton 1994). Human presence within bald eagle use areas was also considered an impact.

6.4.4 Effect of Toxicological Agents

Methods employed to assess effects of toxicological agents are described in Section 4.4.3.

6.5 RESULTS

6.5.1 Effect of BRAC-Related Construction to Bald Eagle Habitat

All construction associated with BRAC actions are located outside bald eagle use areas (Figure 6-3). Ballard Mobile Smoke Training Area includes construction along Roubidoux Creek, but this area is unsuitable for bald eagle use.

6.5.2 Effect of Human Presence

All training activities associated with BRAC actions are located outside bald eagle use areas (Figure 6-3). Ballard Mobile Smoke Training Area includes training along Roubidoux Creek, but this area is unsuitable for bald eagle use. Activity at the FOX Vehicle Swim is within 400 m of Big Piney River, but has sufficient screening vegetation to prevent activity from disturbing bald eagles. This area was thoroughly discussed in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a).

6.5.3 Effect of BRAC-Related Sound on Wintering Bald Eagles

Characteristics of sounds produced by mobile smoke generators and decontamination equipment are shown in Appendix I. These data were necessary for sound modeling and are provided as reference material.

Background sound levels (near caves) on the Big Piney River and Roubidoux Creek at Fort Leonard Wood ranged from 65 to 75 dB (3D/Environmental 1996a). To determine sound levels of an activity (e.g., construction) in the presence of background sound, we used standard methods of addition of multiple sound sources (Harris 1991). Propagation of sound produced by construction equipment was previously modeled (3D/Environmental 1996a). Those results are incorporated by reference. Construction equipment generated a peak sound pressure level of 125 dB at the source (3D/Environmental 1996a). The nearest construction site (fencing parking lot on TA 250) to an eagle use area is approximately 500 m from Big Piney River (Figure 6-3). At

this distance (Ongoing Mission BA, Table I-21c. 5-8, 3D/Environmental 1996a), sound from construction is estimated to increase background sound pressure levels within eagle use areas by less than 10 dB.

Results of sound propagation modeling from mobile smoke training areas and decontamination equipment are shown in Appendix II. Because bald eagles are only known to use the installation during winter, we consider sound propagation only during winter conditions. Sound levels (in dB) under different winter weather conditions and distances from the source can be directly read from the tables. For example, sound from twelve M157 smoke generators under overcast, windy (wind from southeast), winter conditions is predicted to be 55 dB at 500 m to the east of the source (Appendix II, Table 1b.6). That sound pressure level would be added to background sound.

M56 and M157 smoke generators produced peak sound pressure levels at the source of 131 dB and 121 dB, respectively. The closest mobile smoke training area to bald eagle use areas is the Cannon Range location (Figure 6-5). At distances greater than 500 m (Appendix II), sound pressure levels generated by mobile smoke generators will be 3 dB or less above background sound levels. Because proposed mobile smoke training areas are a minimum of 645 m from the banks of Roubidoux Creek (245 m from bald eagle use areas), sound levels reaching eagle use areas will be approximately 2 to 8 dB above background levels.

The peak sound pressure level measured from decontamination equipment was 107 dB. The closest proposed decontamination site to a bald eagle use area is approximately 500 m from Roubidoux Creek (Figure 6-4). Decontamination training at this site will increase background sound levels within bald eagle use areas by less than 1 dB. Sound propagation modeling results show decontamination equipment will generate sound approximately 1 dB or less above background sound levels at distances greater than 500 m (Appendix II). Because other sites are at least 500 m from eagle use areas, sound from these sites were not considered further.

Our review of recent literature yielded no further guidance for determining thresholds for sound levels causing disturbance to wintering bald eagles or other raptors. An increase from background sound of 10 dB or more within eagles use areas (400 m from stream banks) was determined to be the best threshold to assess impacts of sound to wintering bald eagles from available scientific or commercial data.

6.5.4 Effect of Toxicological Agents

Information pertinent to this toxicological evaluation describing seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history are provided in Section III of Appendix IV. Descriptions of local geomorphology, soils, groundwater, surface water, climate, and natural resources are provided in Appendix IV, Section IV.

6.5.4.1 Fog Oil

Toxicity

Chemical properties and a general description of fog oil is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of fog oil via ingestion, dermal absorption, and inhalation exposure. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when bald eagles forage. Three bald eagle nests occur north of the installation (Figure 6-2). Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of fog oil in air, and the rate at which fog oil is deposited in various atmospheric conditions are described in Appendix IV, Section VIII. Figures 4-9 and 4-10 are representative examples of fog oil dispersion from static and mobile training areas in Pasquill atmospheric stability category E. Dispersion of fog oil in Pasquill categories B - E is described and plotted in Appendix IV, Section VIII. Figures 4-11 and 4-12 are representative examples of fog oil deposition downwind of static and mobile training areas in Pasquill atmospheric stability category E. Additional estimates of fog oil deposition are provided in Appendix IV, Attachment B. Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section 8.4. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment E.

Risk

The risk of acute and chronic effects (at varying distances from the fog oil source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment H. Effects to bald eagles are anticipated where HQs exceed 1.0. Effects to bald eagles are summarized in Table 4-12.

6.5.4.2 Terephthalic Acid

Toxicity

Chemical properties and a general description of terephthalic acid is provided in Appendix IV, Section V. Section 7.2 of Appendix IV describes the toxicity of TPA. The carcinogenic/teratogenic properties of fog oil are discussed in Appendix IV, Section 7.2.2.6.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. Bald eagles forage nearly installation-wide and may be exposed during this activity. Bald eagles in nests north of the installation also have potential for exposure (Figure 6-6). Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

TPA grenade and smoke pot dispersion was modeled for Pasquill atmospheric stability category B (Figures 4-13 and 4-14). Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section VIII. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment E.

Risk

The risk of acute and chronic effects (at varying distances from the TPA source is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment H. Effects to bald eagles are anticipated where HQs exceed 1.0. Effects of proposed TPA training on bald eagles are summarized in Table 4-12.

6.5.4.3 Titanium Dioxide

Toxicity

Chemical properties and a general description of titanium dioxide is provided in Appendix IV, Section V. Section 7.5 of Appendix IV describes the toxicity of titanium dioxide. The carcinogenic/teratogenic properties of titanium dioxide are discussed in Appendix IV, Section 7.5.1.5.

Exposure

We summarize information regarding seasonal occurrence, activity periods, habitat preferences, physiology, morphology, diet, behavior, and other aspects of life history in Appendix IV, Section III. In general, there is potential for exposure nearly installation-wide when bald eagles forage. Bald eagles in 3 nests north of the installation also have potential for exposure. Characteristics of local geomorphology, soils, groundwater, surface water, climate, and natural resources that may affect exposure are described in Appendix IV, Section IV.

The dispersion of titanium dioxide in air was modeled for Pasquill atmospheric stability category E (Figure 4-15). Appendix IV, Section VIII summarizes meteorological conditions in caves that affect exposure of receptors.

Intake

Calculations of acute (single exposure) and chronic (lifetime) intake are described in Appendix IV, Section VIII. These calculations address distance from the source, exposure frequency, exposure duration, body weight, stressor concentration, life span, intake rate, and a number of other variables. Calculations of intake are include in Appendix IV, Attachment E.

Risk

The risk of acute and chronic effects (at varying distances from the titanium dioxide source and in varying atmospheric stabilities) is summarized in Appendix IV, Section IX; and detailed in Appendix IV, Attachment H. Effects to bald eagles are anticipated where HQs exceed 1.0. Effects to bald eagles are summarized in Table 4-12.

6.6 EFFECTS ANALYSIS/DISCUSSION

6.6.1 Effect of BRAC-Related Construction to Bald Eagle Habitat

6.6.1.1 Wintering Bald Eagles

A "may affect finding" will be made if potentially disturbing activities occur as a result of BRAC actions within 400 m of the Big Piney River or Roubidoux Creek, or if construction in tributary streams sufficiently degrades water quality and reduce prey (fish) availability.

Grubb and King (1991) found proximity to be the prime determinant of whether bald eagles respond to human-induced disturbances and sound to be least influential disturbance on eagles. McGarigal et al. (1991) found human presence in potential eagle foraging areas can influence eagles to choose other foraging areas. Two proposed construction sites are within bald eagle use areas. Construction will occur adjacent to Fox Vehicle Swim on TA 250, 200 m from Big Piney River, but this area is screened from eagle view by intervening riparian vegetation. Construction here should have no adverse impact to wintering bald eagles. Development of Ballard Mobile Smoke Training Area includes construction within 400 m of Roubidoux Creek in an area of currently unsuitable habitat for wintering eagles. This construction will not affect wintering bald eagles.

Decontamination training moved to Fort Leonard Wood as part of the BRAC action will not adversely impact physical characteristics of eagle habitat.

Construction activity, including felling and clearing of trees, resulting from BRAC actions could impair water quality and reduce the quality of feeding habitat for bald eagles. Much construction activity resulting from BRAC actions will occur in tributary watersheds of Roubidoux Creek, away from areas used by wintering eagles. A project design (see Section 2.2.3) will assure erosion at construction sites will not affect bald eagle habitat.

6.6.1.2 Nesting Bald Eagles

Given the typical size of nesting eagle home ranges, it is unlikely bald eagles nesting around Fort Leonard Wood have foraging ranges large enough to include the Installation. BRAC construction activities are not expected to affect nesting bald eagles or their habitat.

6.6.2 Effect of Human Presence

6.6.2.1 Wintering Bald Eagles

A "may affect finding" is appropriate if potentially disturbing human presence is expected, as a result of BRAC actions, within 400 m of the Big Piney River or Roubidoux Creek.

Two proposed construction sites will require human presence within bald eagle use areas. Construction of the Fox Vehicle Swim on TA 250 is 200 m from Big Piney River. This area is screened from eagle view by intervening riparian vegetation. Human presence during construction will be screened by intervening vegetation. No adverse impacts to wintering bald eagles are expected. Development of Ballard Mobile Smoke Training Area includes construction within 400 m of Roubidoux Creek in an area of currently unsuitable habitat for wintering eagles. Human presence in this area will not affect wintering bald eagles

The presence of personnel during decontamination training may disturb eagles if it occurs within 400 m of wintering eagles. Of the 8 potential sites for hasty decontamination training, six are located well away from areas used by wintering eagles. The 2 least preferred sites either are on, or near, Roubidoux Creek. Site WM 693705 is located approximately 500 m north of Roubidoux Creek, outside the 400 m disturbance restriction zone. Site WM 734815 is on Roubidoux Creek in the northwestern corner of the Installation within Ballard Mobile Smoke

Training Area. This section of Roubidoux Creek is unsuitable for bald eagle habitat. Human presence at these sites should not affect wintering bald eagles.

6.6.2.2 Nesting Bald Eagles

No nests are known to occur on Fort Leonard Wood. Human presence within the Installation should not affect nesting bald eagles.

6.6.3 Effect of BRAC-Related Sound on Wintering Bald Eagles

Sound from proposed BRAC activities outside bald eagle use areas on Fort Leonard Wood will not affect bald eagles. Sound modeling indicates locations of proposed training and construction sites are adequately distanced from eagle use areas to not increase sound levels in bald eagle use areas by 10 dB.

Buehler et al. (1991) found bald eagles, when approached, flushed at greater distances in winter than in summer. This suggests bald eagles may be more sensitive during winter than summer, although decreased vegetation and improved visibility might also account for their observation. Regardless, it is clear certain activities result in displacement flights of wintering bald eagles from their perches. These flights result in unnecessary energy expenditures and may cause increased stress (i.e., other physiological effects).

Stalmaster and Newman (1978) concluded that bald eagles were tolerant of auditory stimuli, especially when the source of the sound was out of view. We found no information in our literature review to construct a guidance for sound level thresholds which disturb wintering bald eagles. We used a 10 dB increase in background sound within eagle use areas as a conservative threshold. We examined potential disturbances to wintering bald eagles from sound generated by proposed BRAC activities outside of eagle use areas by modeling sound to determine levels reaching eagle use areas. Results of sound propagation modeling indicate sound levels generated by BRAC-related construction and training will be only slightly above background sound levels at distances of 500 m from their sources. Given the moderate expected increases in sound levels (1 to 8 dB), we do not expect sound generated by BRAC-related construction or training outside of eagle use areas to impact bald eagles wintering on Fort Leonard Wood.

Wintering bald eagles are more likely to be affected by visual stimuli or visual and sound, than sound alone. In addition, anthropogenic stimuli such as humans on foot or in boats (Buehler et al. 1991, Knight and Knight 1984) may disturb eagles more than vehicle or airplane traffic. Stalmaster and Newman (1978) showed wintering bald eagles permitted closer approaches when researchers were screened by dense vegetation than when researchers walked in open meadows or in the river channel where they were in view.

Human activities, including the sound generated by these activities, within 400 m of wintering bald eagle use areas have the greatest potential to impact bald eagles on Fort Leonard Wood. We found no information suggesting FWS guidelines (1983) restricting human activity within 400 m of wintering bald eagles are unreasonably conservative.

6.6.4 Effect of Toxicological Agents

A number of proposed training activities may expose bald eagles to unsafe concentrations of stressors. We assessed acute and chronic effects. The discussion below focuses upon effects summarized in Table 4-12. We estimate the number of eagles to be affected where we predict acute or chronic effects. Estimates of the number of eagles to be affected are based upon the following assumptions:

- No bald eagles utilize the installation during the summer.
- Our estimate of the number of bald eagles on the installation during the winter was developed by calculating the mean number (13) of bald eagles sighted on or adjacent to the Installation during aerial surveys between 1988 and 1995.
- We assume wintering bald eagles may occur installation-wide. We assume bald eagles perch only along the Roubidoux Creek and Big Piney River.
- We assume there are 3 active bald eagle nests north of the installation. We assume 2 adults and 2 young occupy each nest during the summer.

6.6.4.1 Static Fog Oil Training

No acute or chronic toxicological effects are expected from static fog oil training (Appendix IV).

6.6.4.2 Mobile Fog Oil Training

No acute or chronic toxicological effects are expected from mobile fog oil training (Appendix IV).

6.6.4.3 Terephthalic Acid Grenades

Acute Effects

Under conditions we assessed, a single exposure to TPA from grenades will affect bald eagles within 3000 m of the source (via *inhalation)*. Bald eagles (traveling or perching - Table 4-12) may occur within 3000 meters of TPA deployment sites. We estimate approximately 13 bald eagles may be affected.

Chronic Effects

No chronic effects are anticipated from TPA grenades.

6.6.4.4 Terephthalic Acid Smoke Pots

Acute Effects

Under conditions we assessed, a single exposure to TPA from smoke pots will affect bald eagles foraging within 3000 m of the source (via *inhalation)*. Bald eagles (traveling or perching - Table 4-12) may occur within 3000 meters of TPA deployment sites. We estimate approximately 13 foraging bald eagles may be affected.

Chronic Effects

No chronic effects are anticipated.

6.6.4.5 Titanium Dioxide Grenades

Acute Effects

No acute effects are expected.

Chronic Effects

No chronic effects are expected.

6.6.5 Cumulative Effects

Effects of the proposed action are described in this biological assessment. Effects of the ongoing mission at Fort Leonard Wood are described in the Biological Assessment of the Master Plan and Ongoing Mission (3D/Environmental 1996a).

Future federal activities in the action area that are not analyzed in this Biological Assessment, or the Biological Assessment of the Ongoing Mission, require action-specific assessment for Endangered Species Act compliance. No non-federal action affecting bald eagles are reasonably certain to occur within the action area. No cumulative effects are anticipated.

6.7 STATEMENT OF FINDING

6.7.1 Effect of BRAC-Related Construction to Bald Eagle Habitat

BRAC construction activities will not affect bald eagles.

6.7.2 Effect of Human Presence

Human presence during BRAC training activities will not affect bald eagles.

6.7.3 Effect of BRAC-Related Sound on Wintering Bald Eagles

Sound from BRAC-related construction or training will not affect wintering or nesting bald eagles on the installation.

6.7.4 Effect of Toxicological Agents

Under conditions we assessed, TPA grenades, and TPA smoke pots may affect bald eagles. If conditions vary from those we used to model dispersion, it is likely the expected effects will decrease.

No cumulative effects are expected. No state or private actions directly or indirectly affecting bald eagles are anticipated within the analysis area and BRAC activities should not compound effects of the ongoing mission.

Section 7
Literature Cited

Section 7.0

Literature Cited

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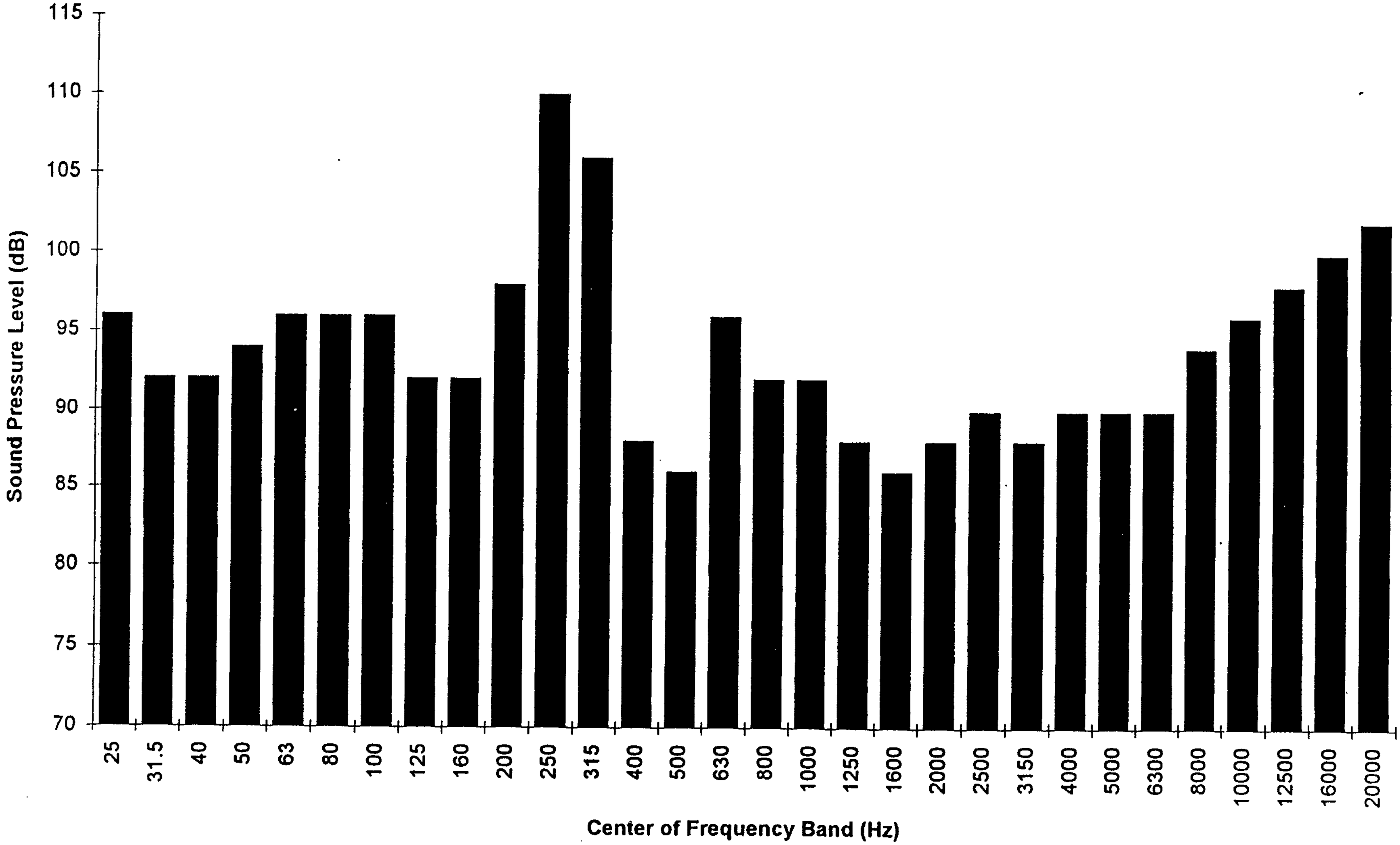
Appendix I
Characteristics of BRAC-Related Sounds Examined for Effects on Fort Leonard Wood's Endangered and Threatened Species

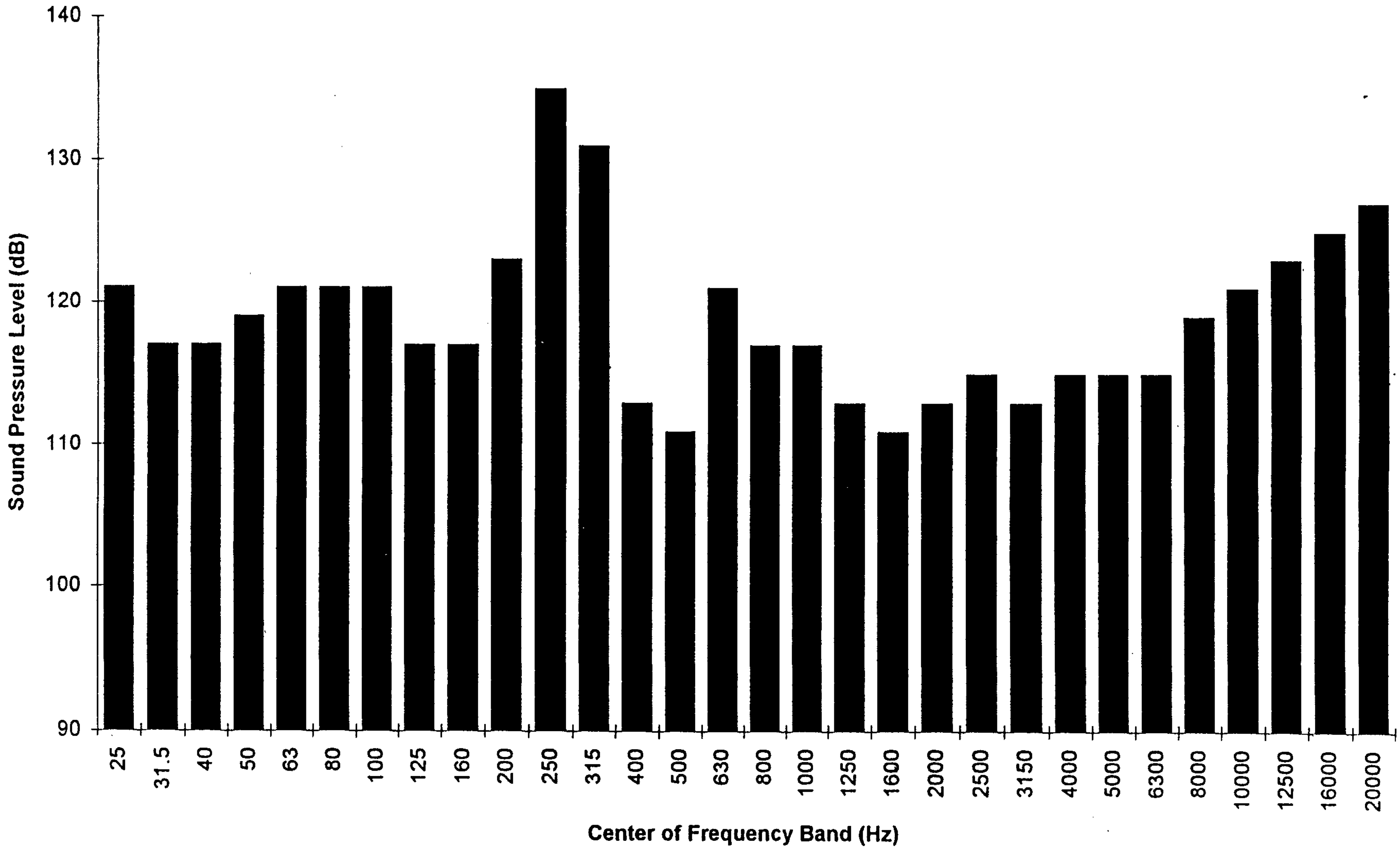
Appendix I

Characteristics of BRAC-Related Sounds Examined for Effects on Fort Leonard Wood's Endangered and Threatened Species

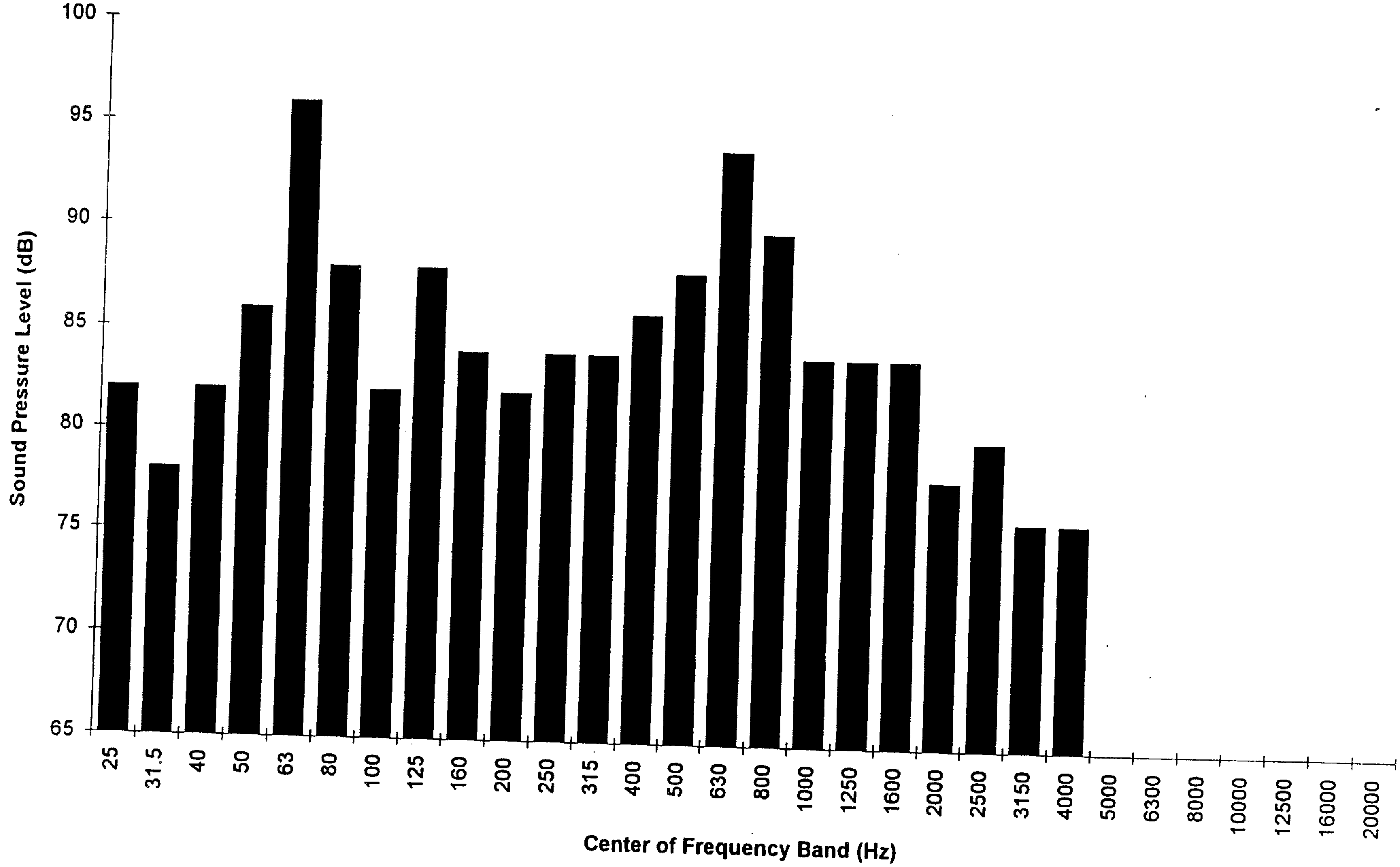
Cumulative Spectrum of M56 Smoke Generator: HMMWV Mounted System at 5m

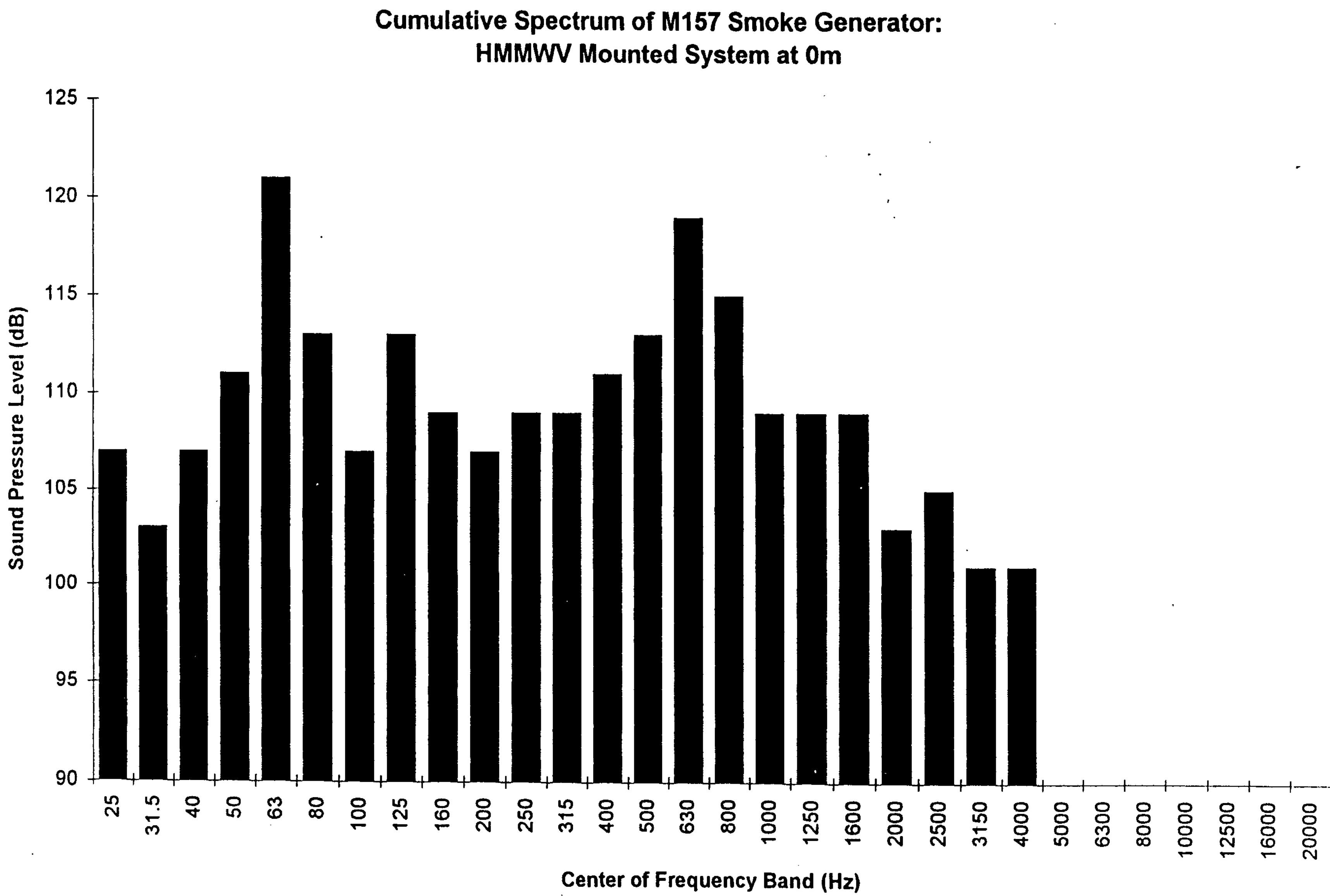


Cumulative Spectrum of M56 Smoke Generator: HMMWV Mounted System at 0m

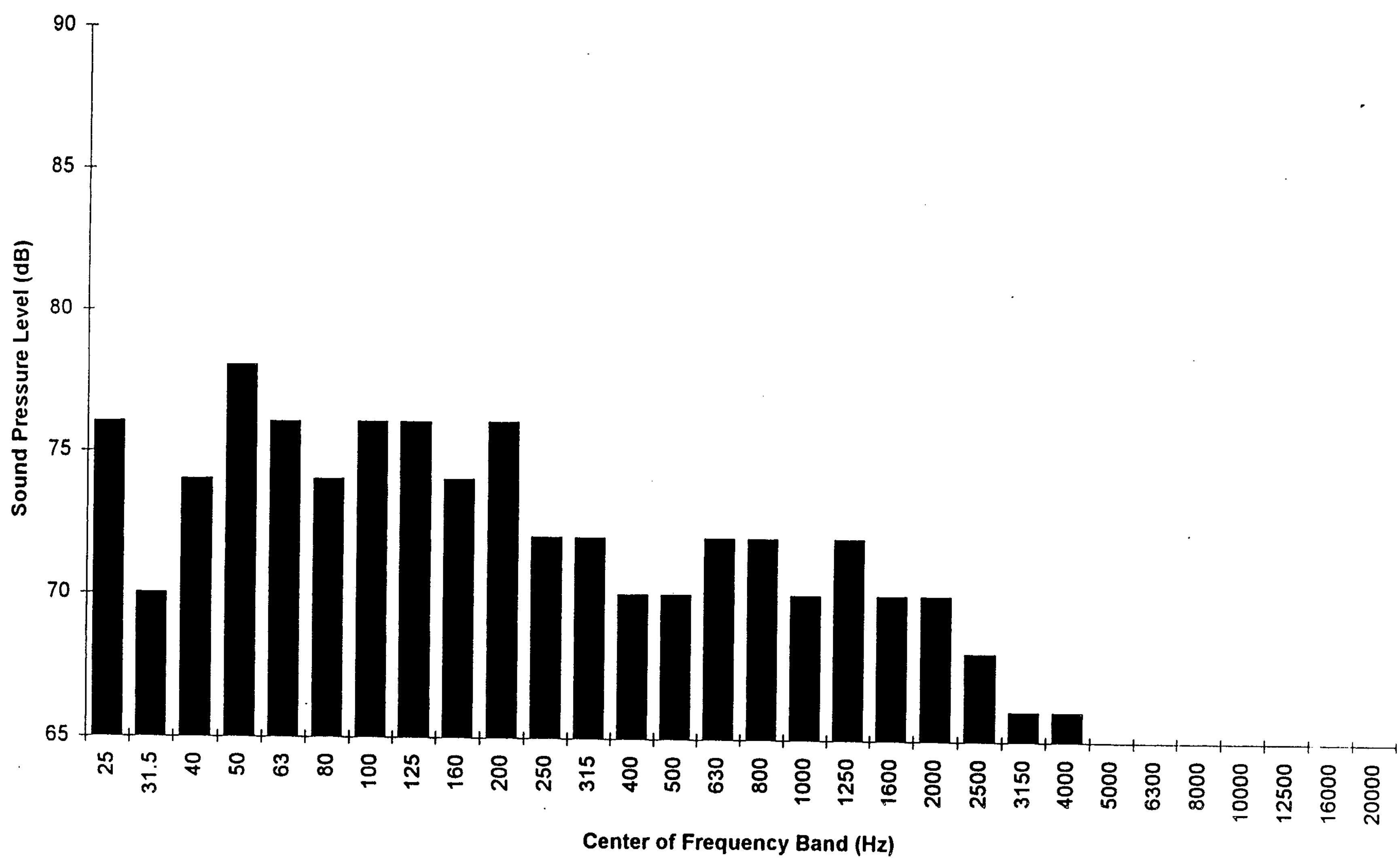


Cumulative Spectrum of M157 Smoke Generator: HMMWV Mounted System at 5m

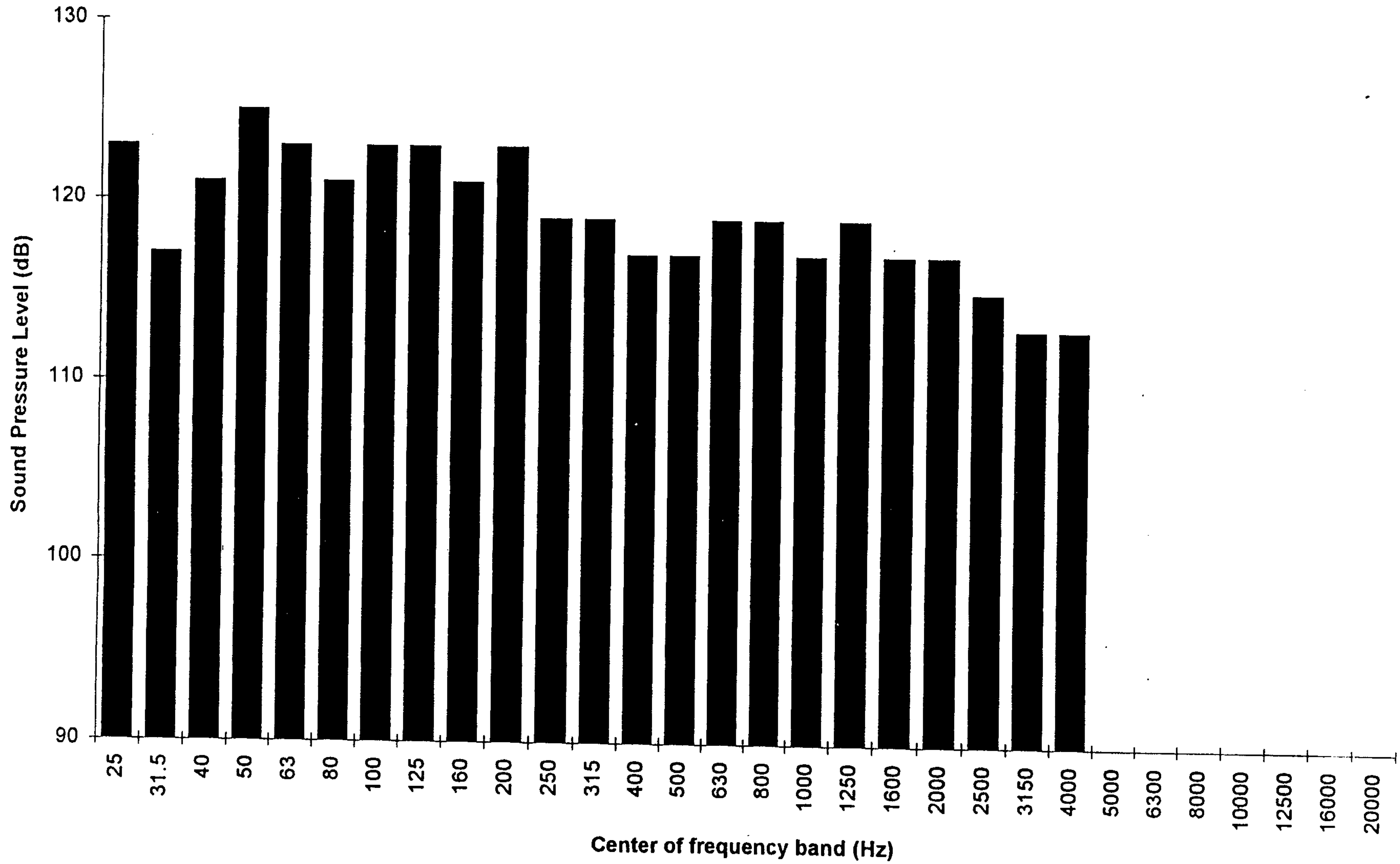



Cumulative Spectrum of M157 Smoke Generator:
HMMWV Mounted System at 0m
Sound Pressure Level (dB)
125
120
115
110
105
100
95
90
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1000
1250
1600
2000
2500
3150
4000
5000
6300
8000
10000
12500
16000
20000
Center of Frequency Band (Hz)

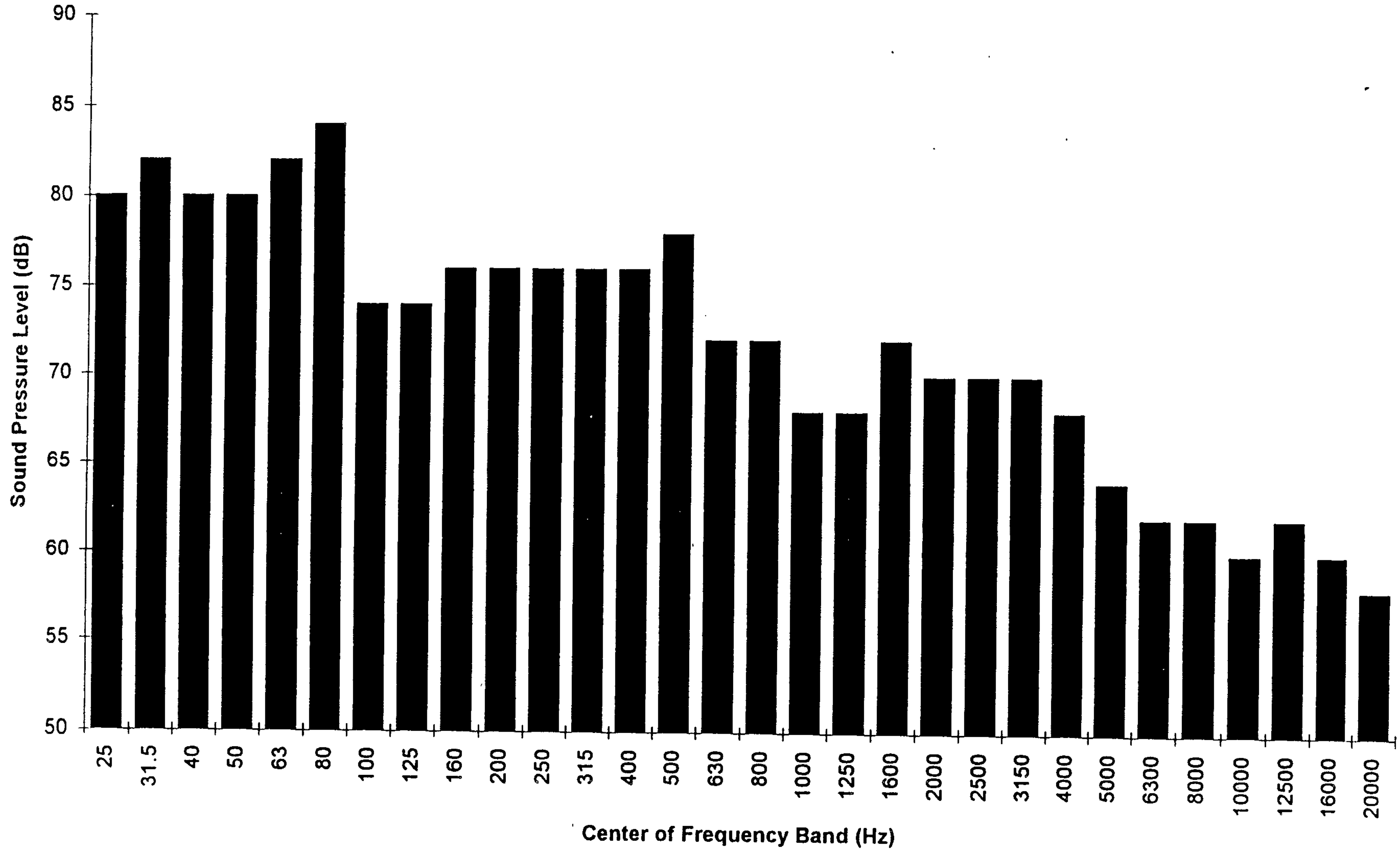
Cumulative Spectrum of Training on 16 Building MOUT Site



Cumulative Spectrum of Training on 16 Building MOUT at 0m



Cumulative Spectrum of USAF Light Decontamination Apparatus at 5m



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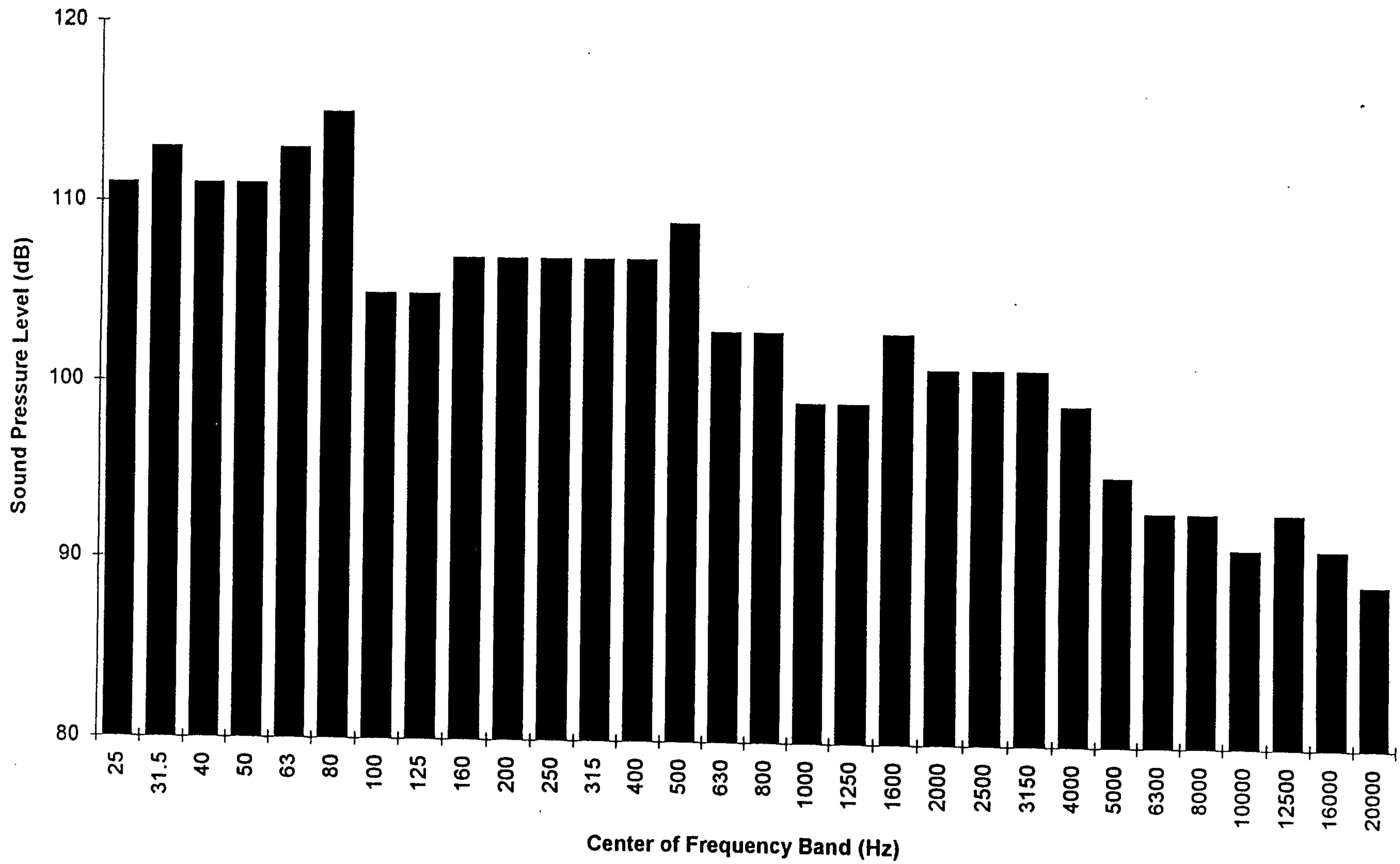
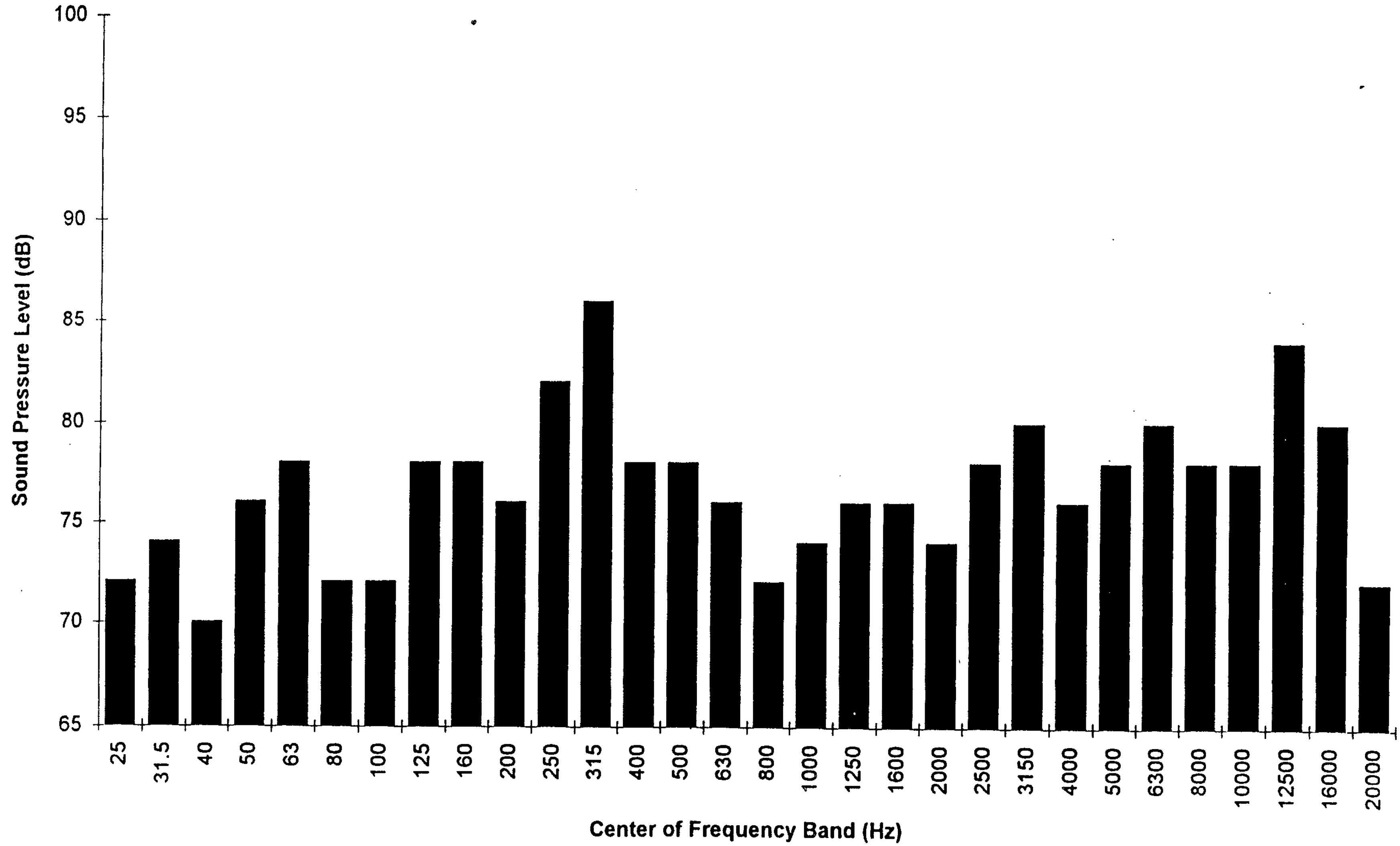
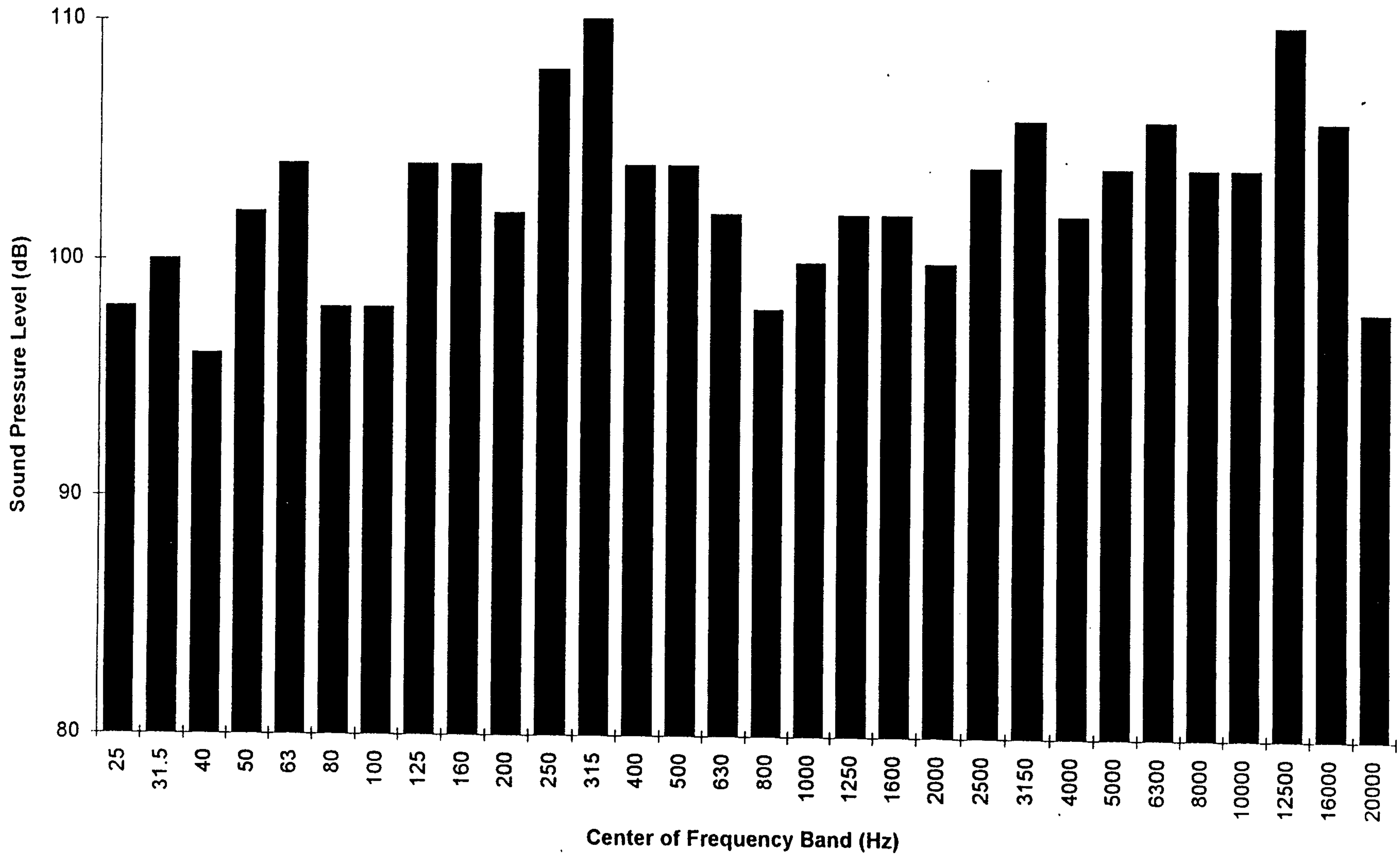


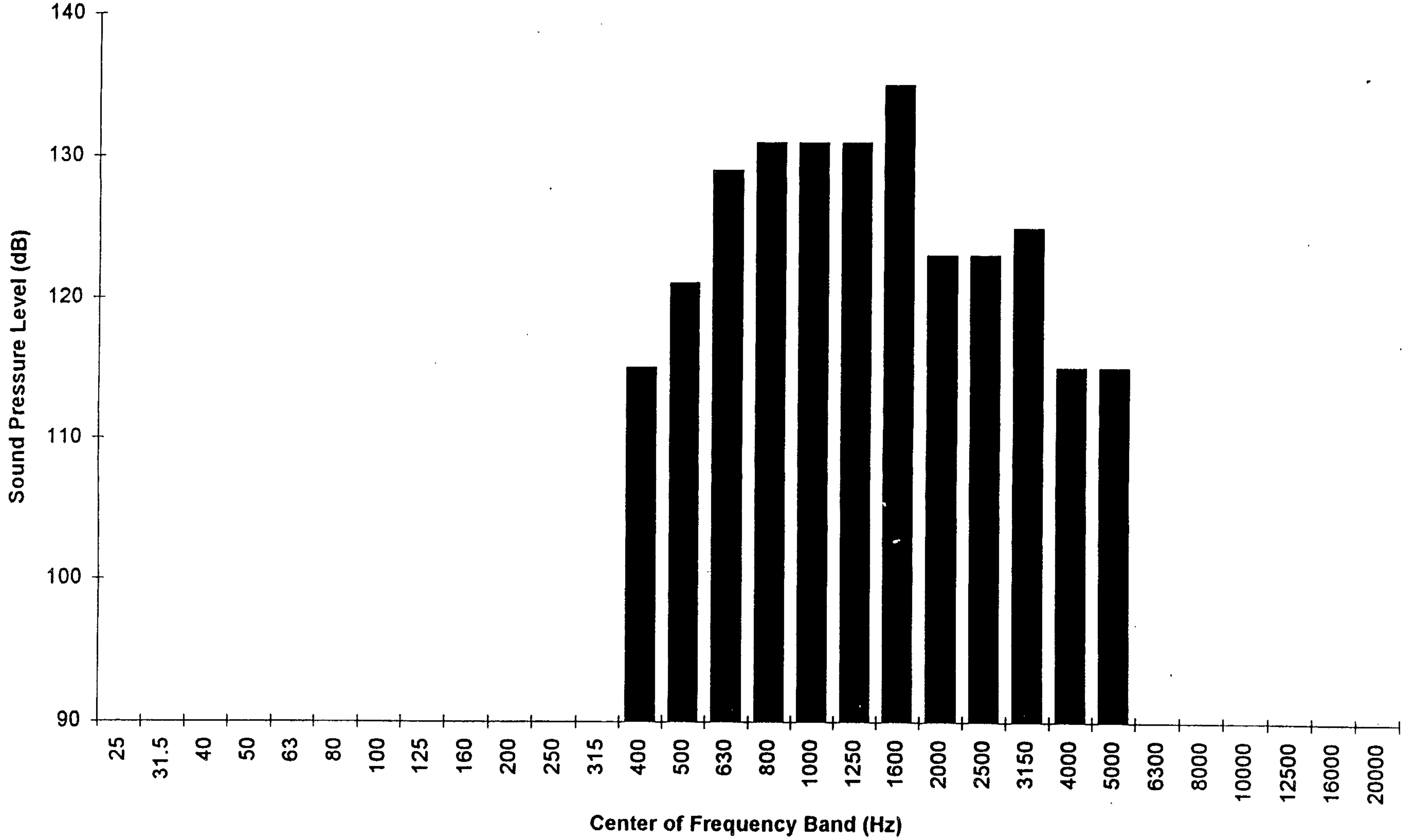
Cumulative Spectrum of USAF Generator and Blower at 5m



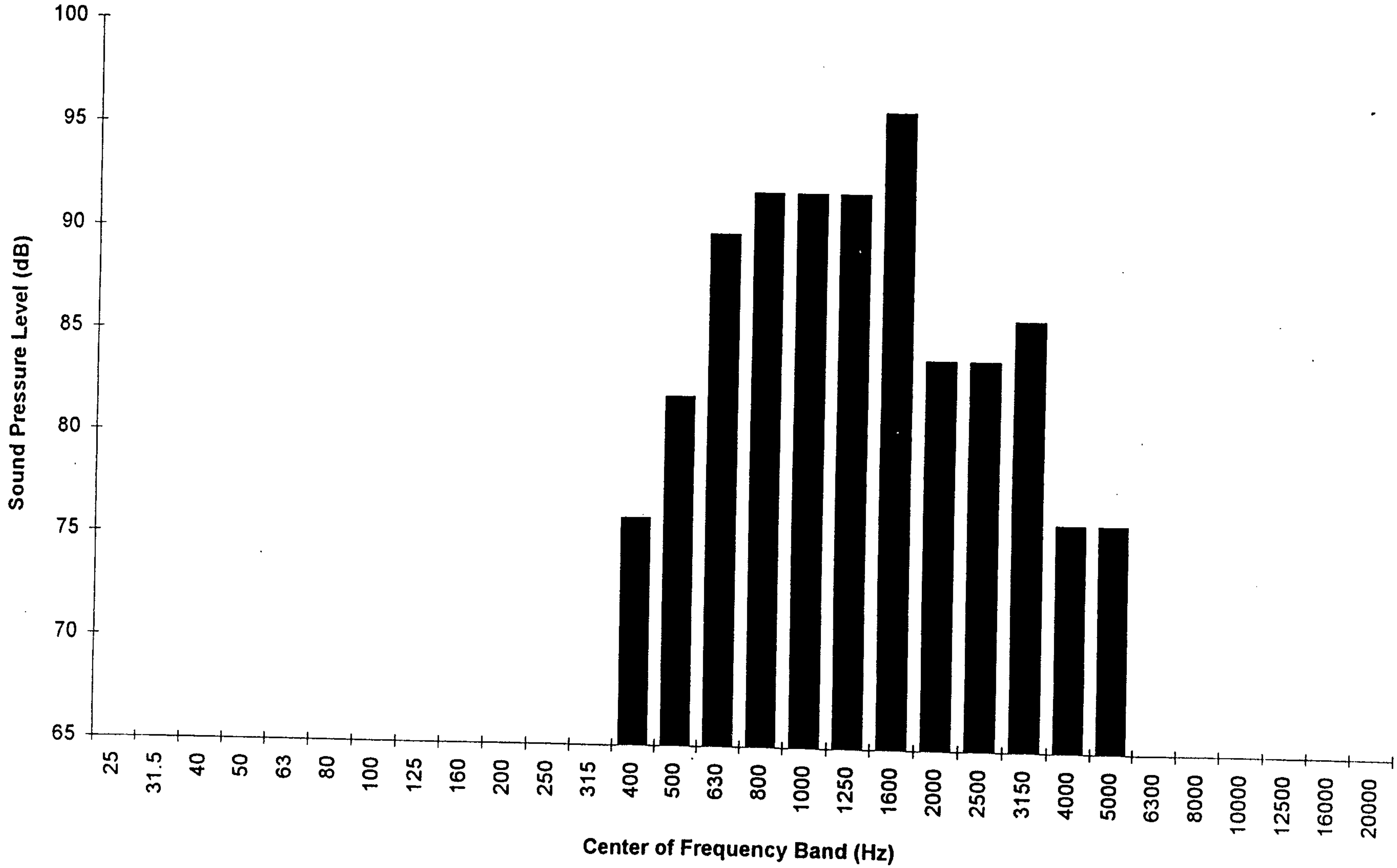
Cumulative Spectrum of USAF Generator and Blower at 0m



Cumulative Spectrum of USAF Siren on Mobile Command Vehicle at 0m



Cumulative Spectrum of USAF Siren on Mobile Command Vehicle at 25m



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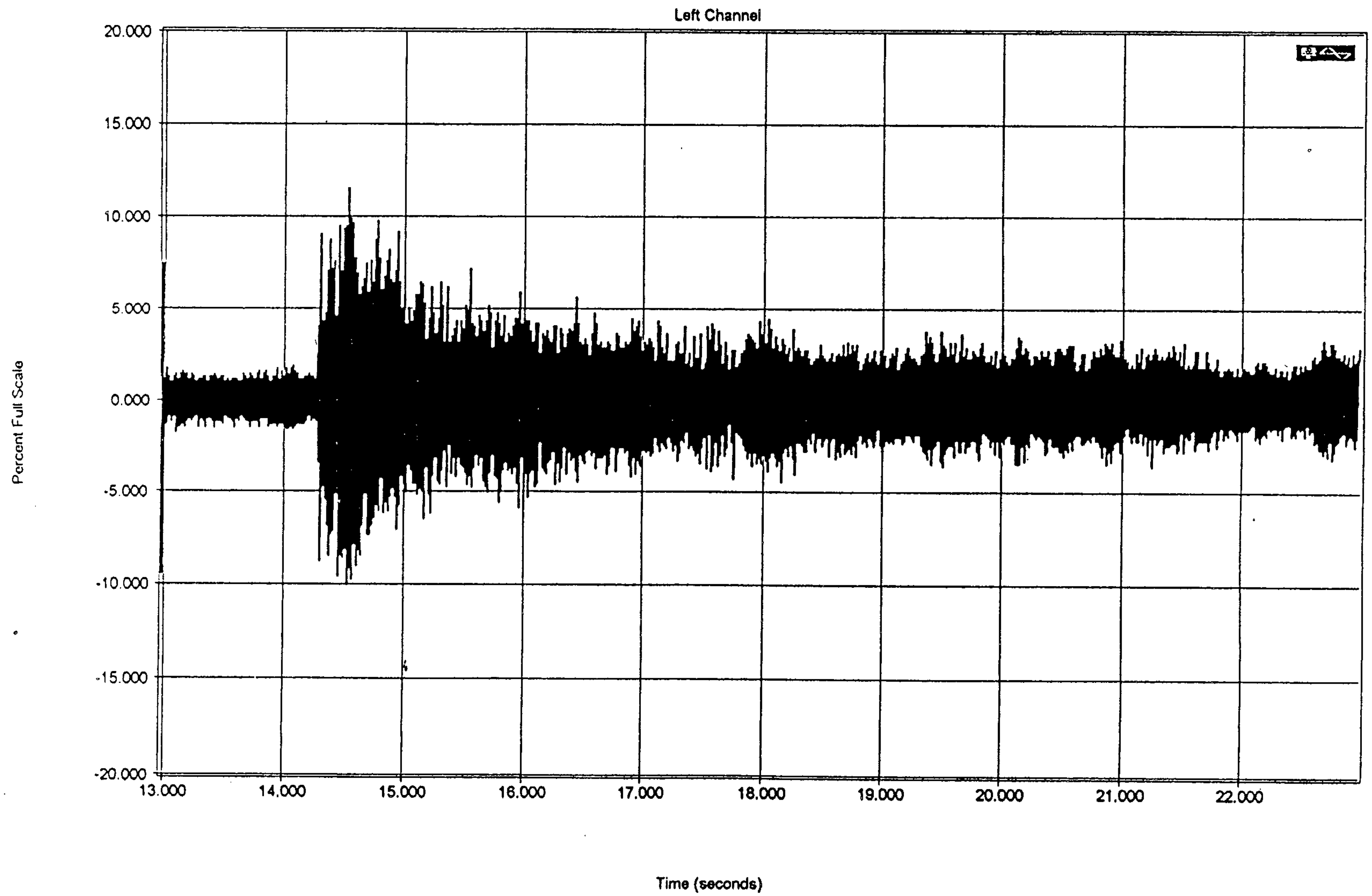
Recording of M56
startup and operation



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Overlap:	85 %

Recording of M56
startup and operation

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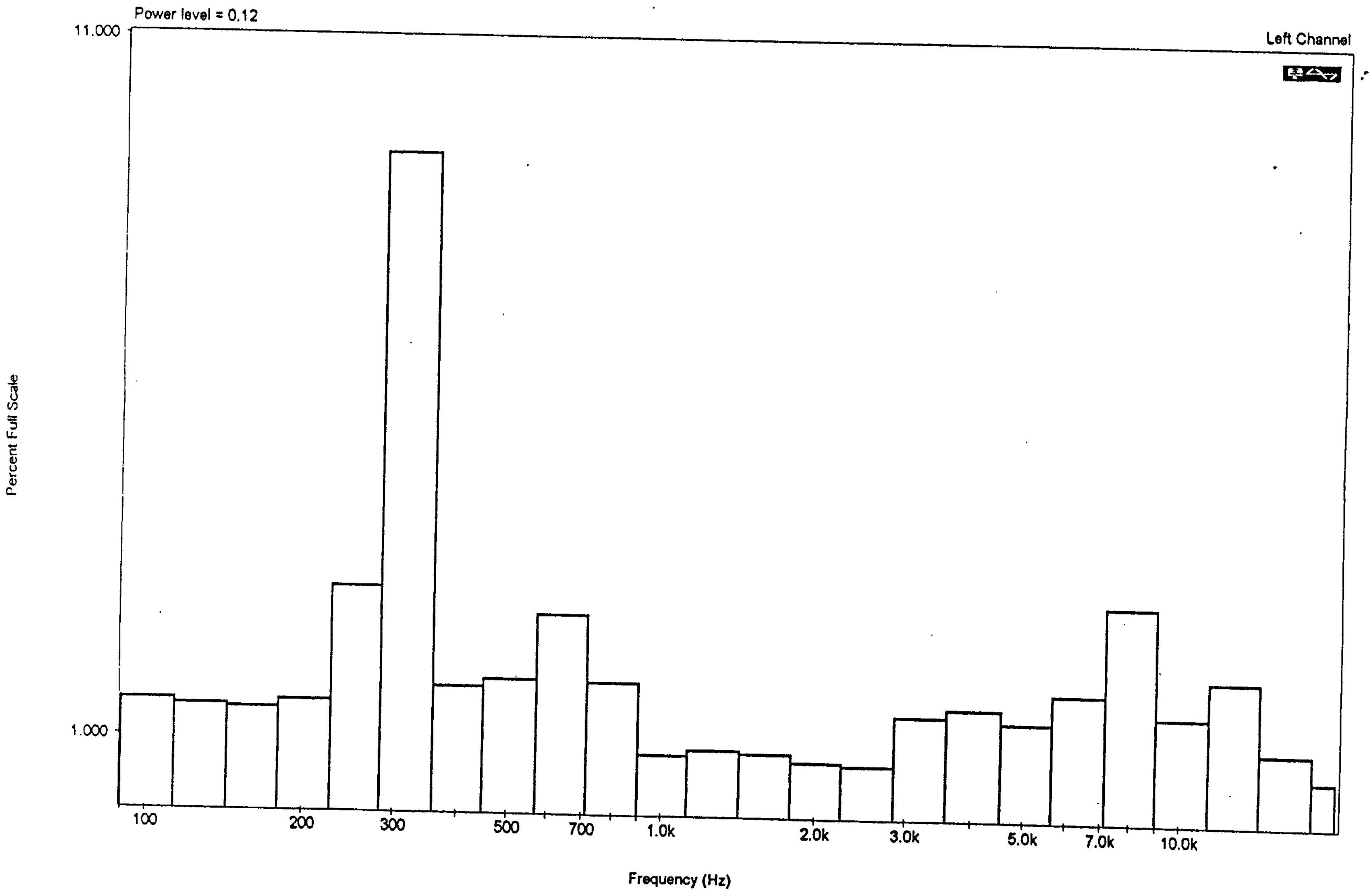

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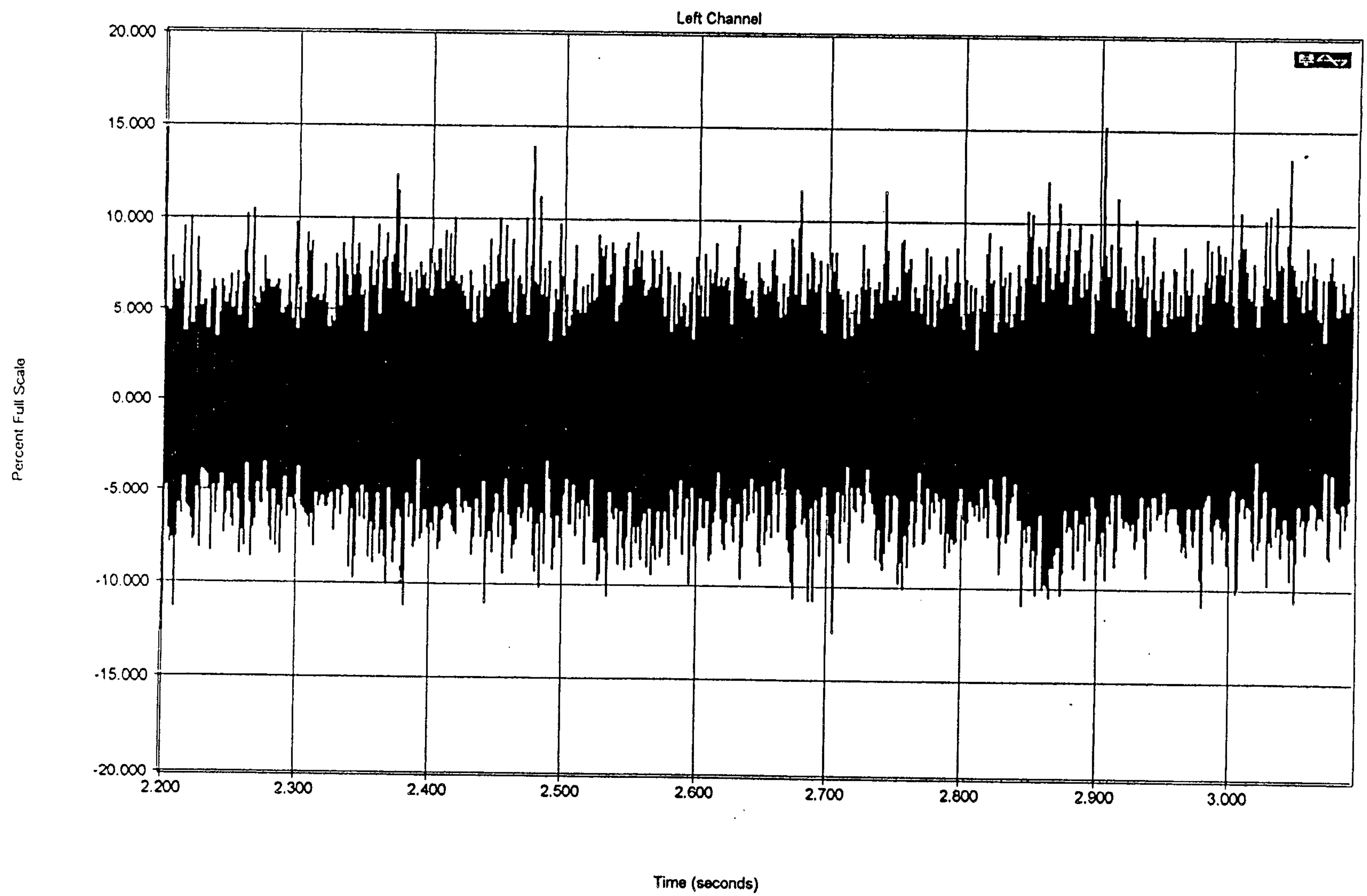
Recording of M56
post-startup operation with grinder



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Window:	Blackman
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Recording of M56
post-startup operation with grinder

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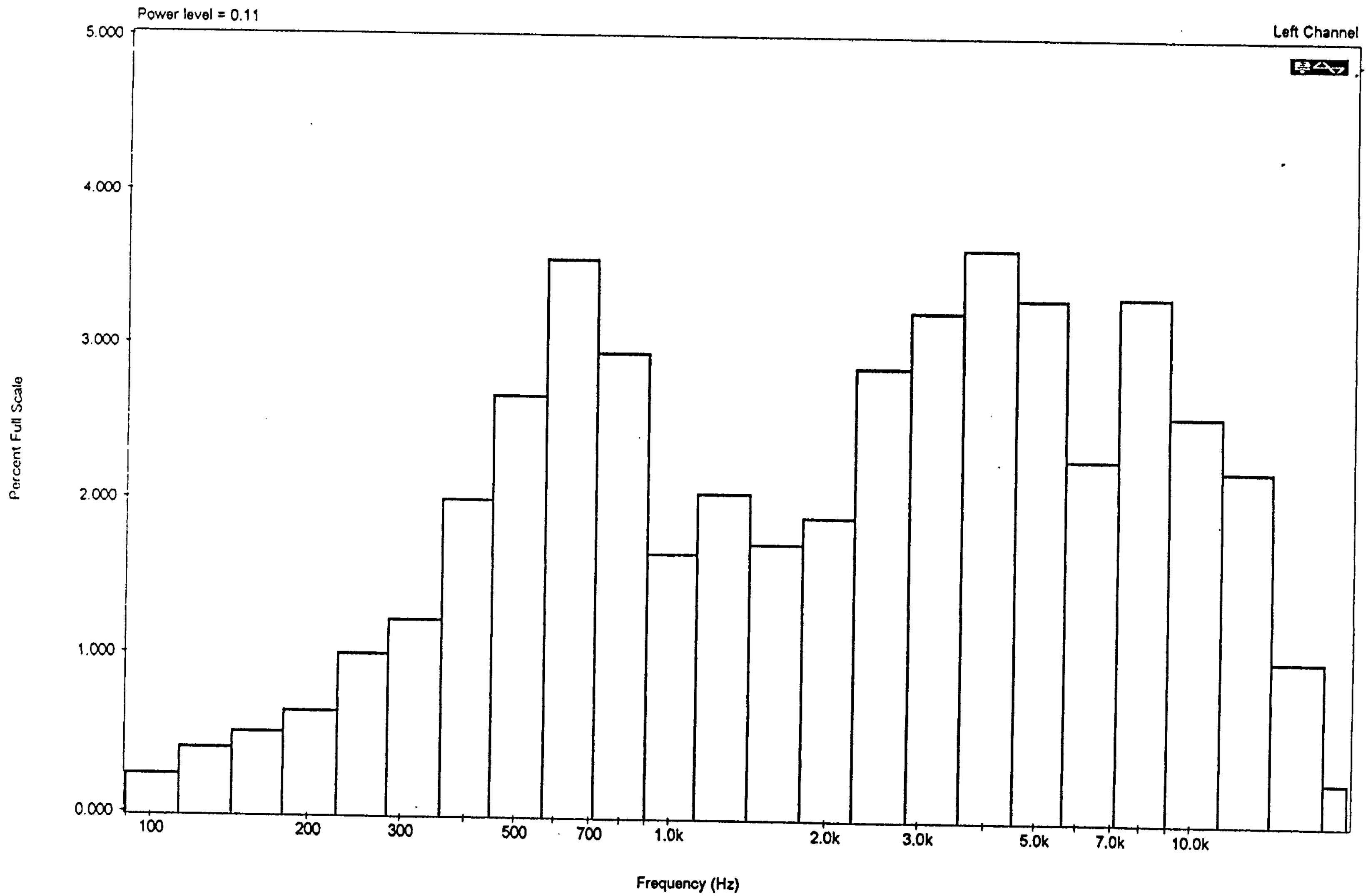

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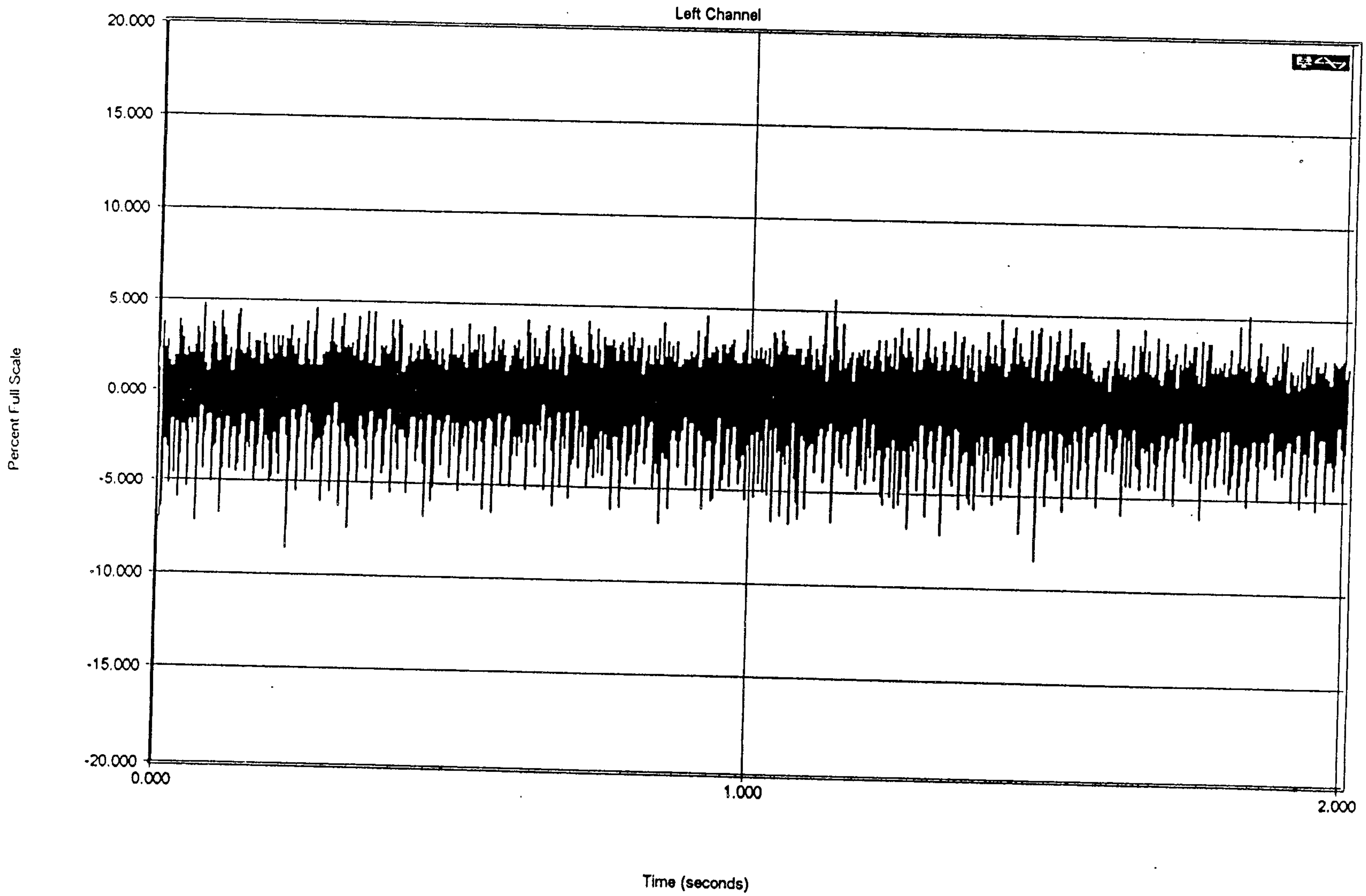

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Recording of M157

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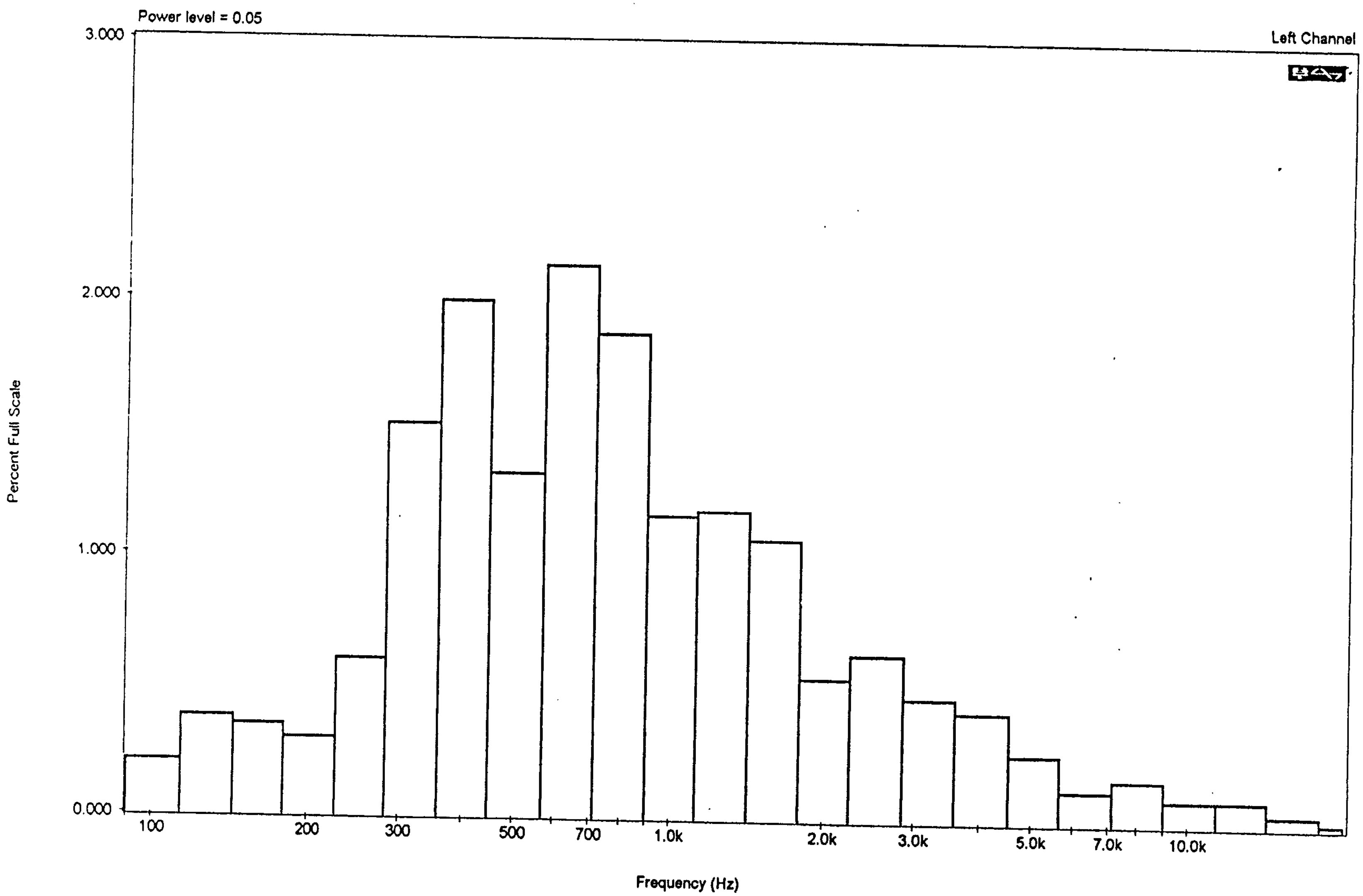

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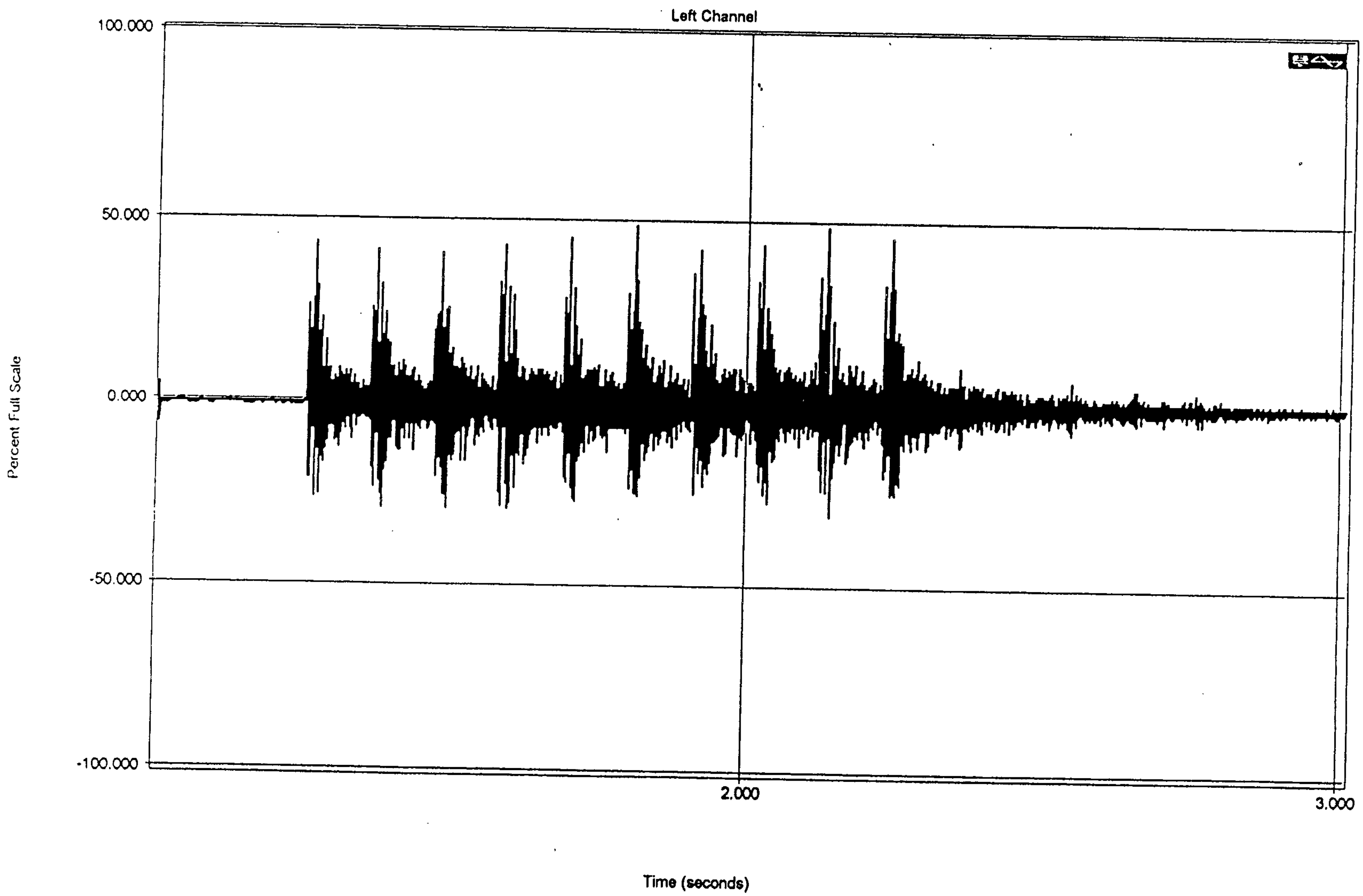
Recording of Machine Gun Fire on MOUT



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Overlap:	85 %

Recording of Machine Gun Fire on MOUT

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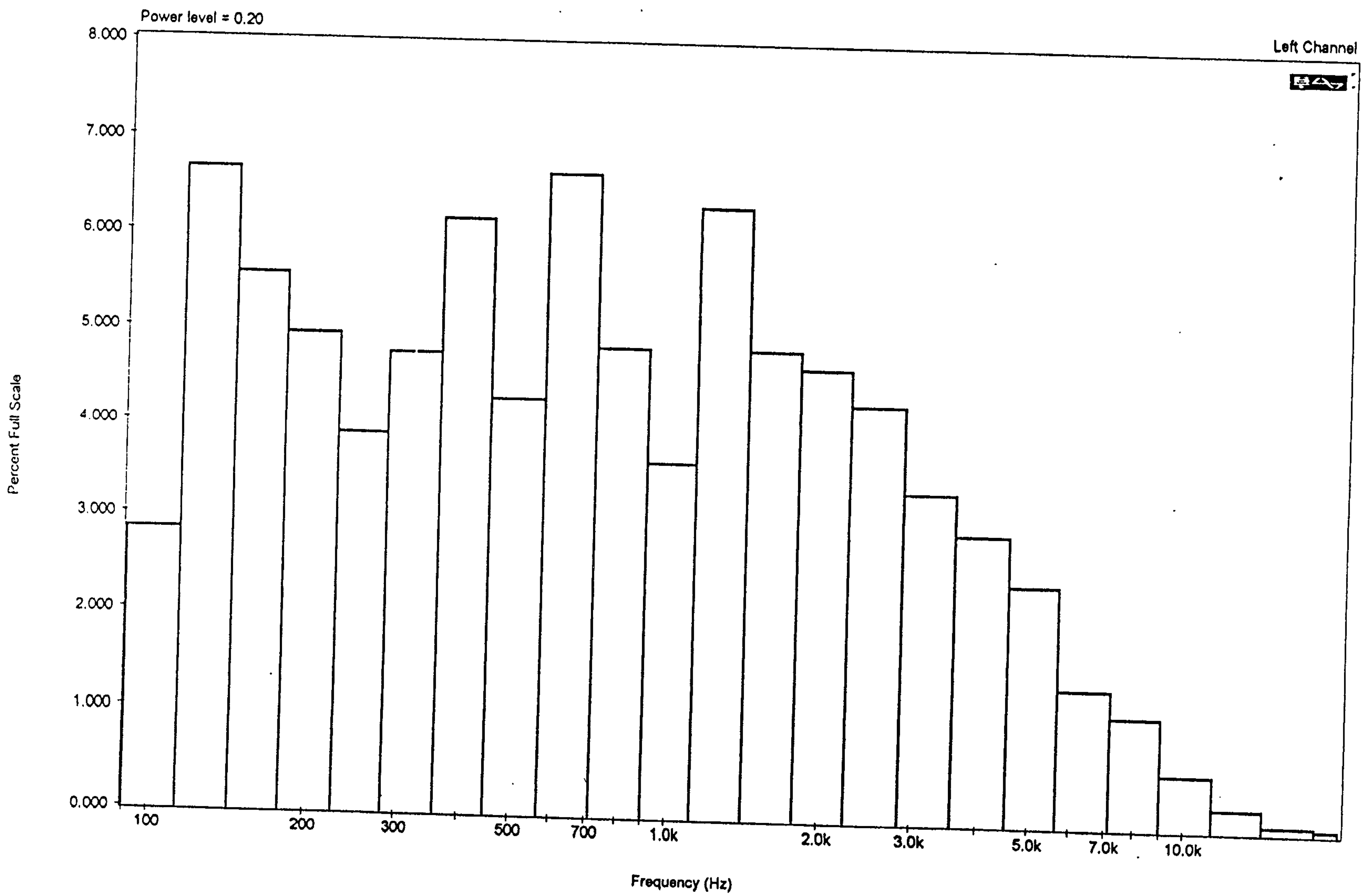

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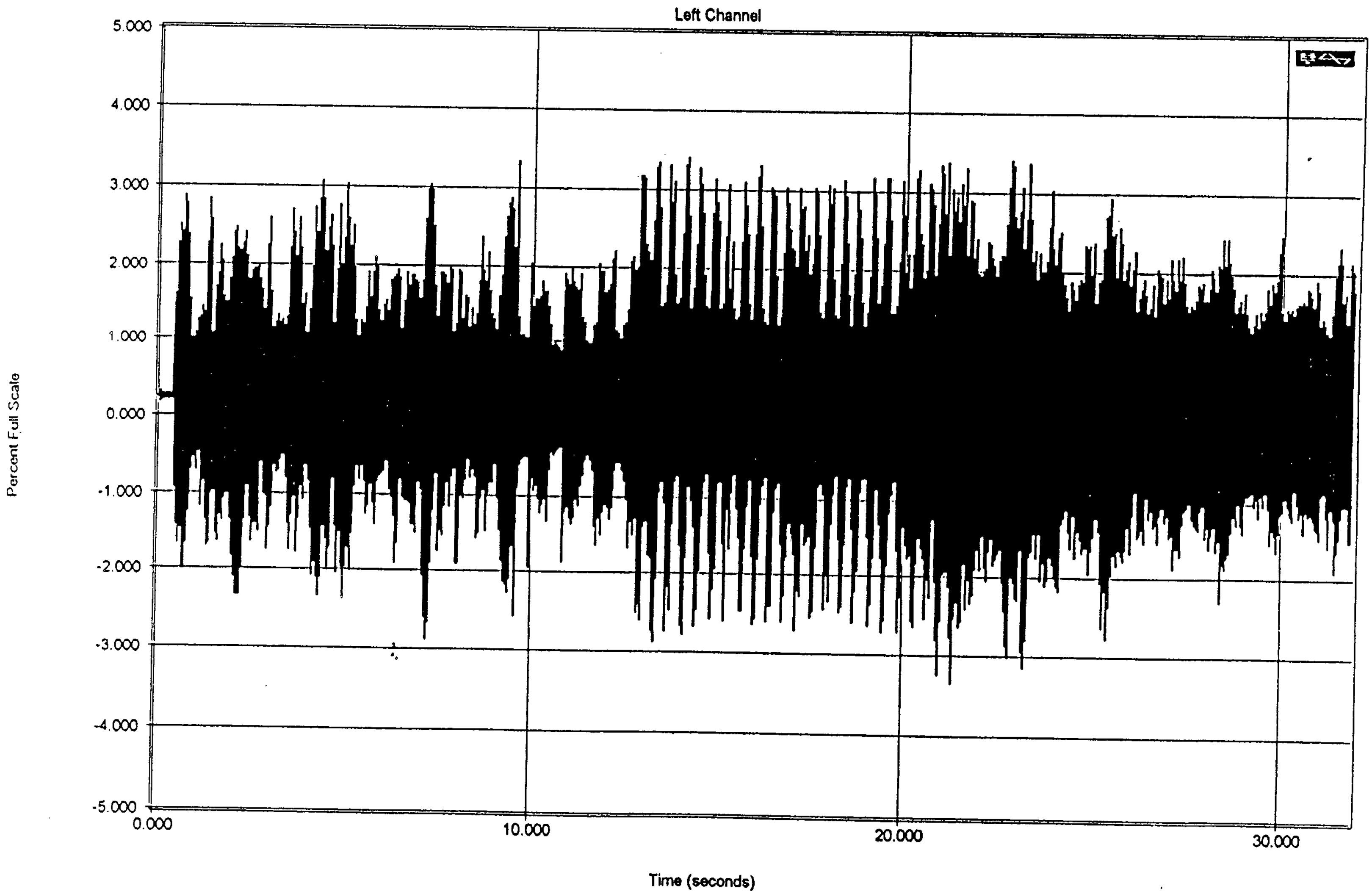
Recording of USAF's Siren on Mobile Command Vehicle



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Recording of USAF's Siren on Mobile Command Vehicle

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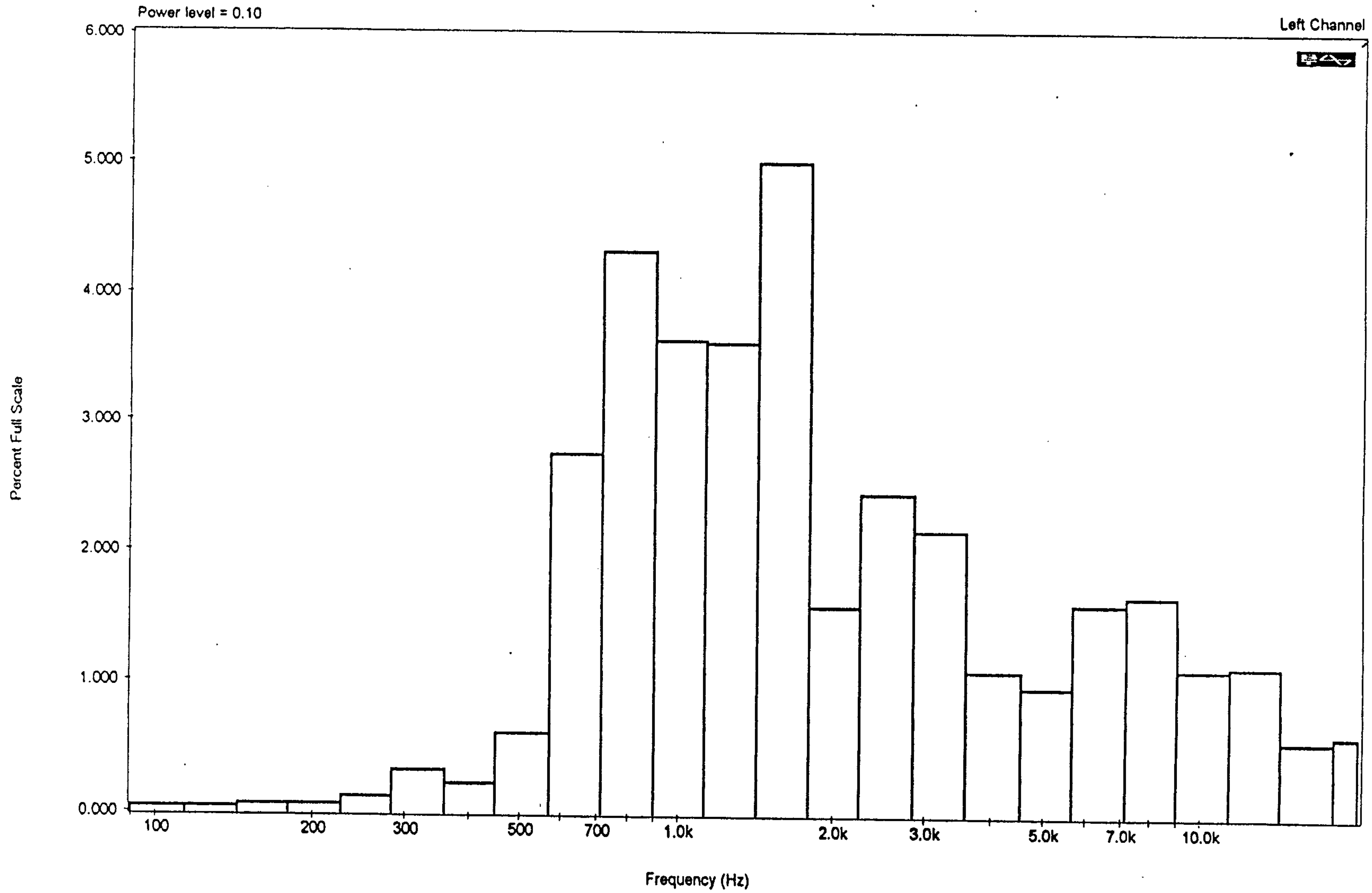

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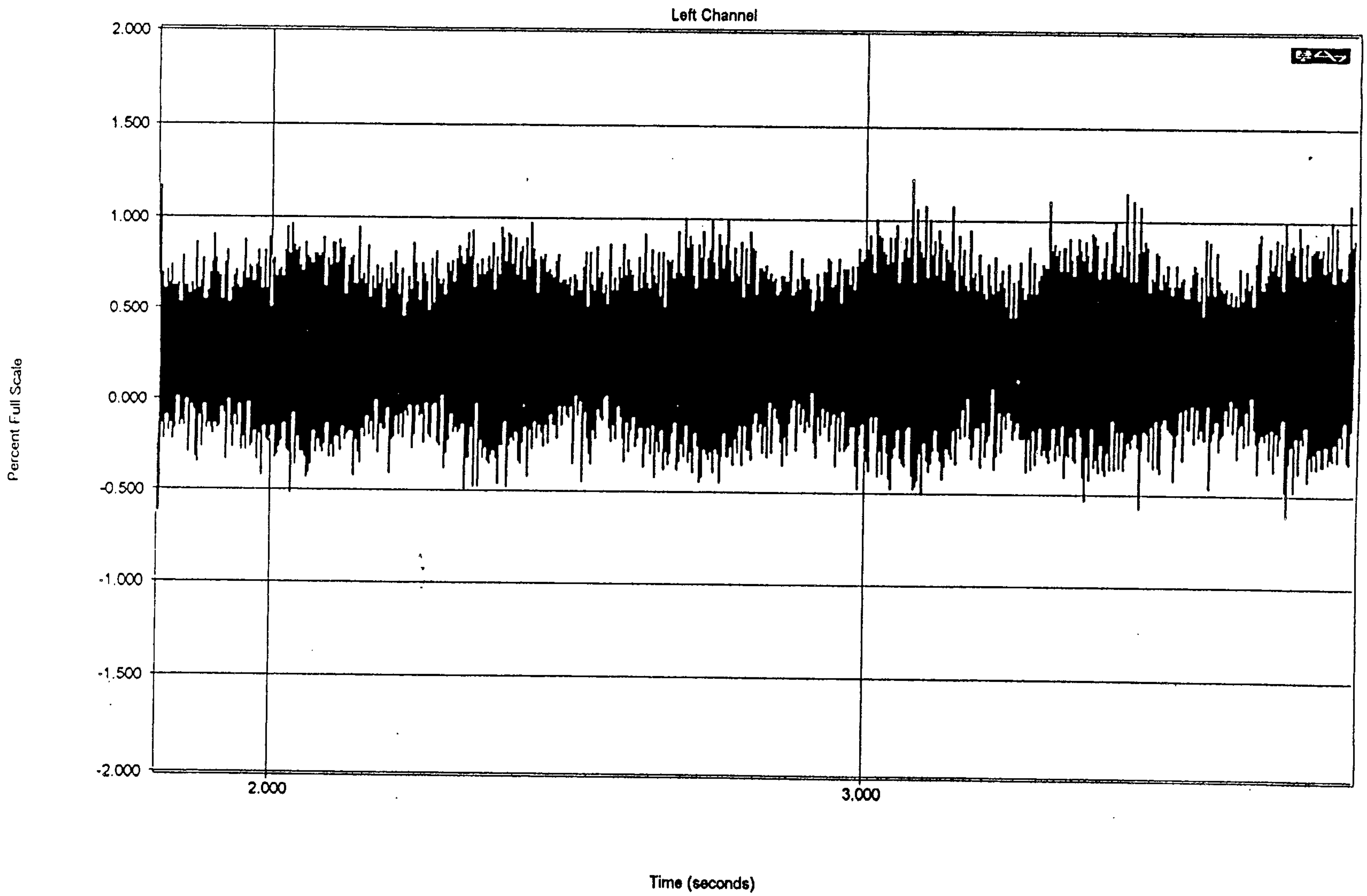
Recording of USAF's Generator and Electric Blower recording made indoors



Sampling: 40228 Hz
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Averaging: 1
Window: Blackman
Overlap: 85 %

Recording of USAF's Generator and Electric Blower
recording made indoors

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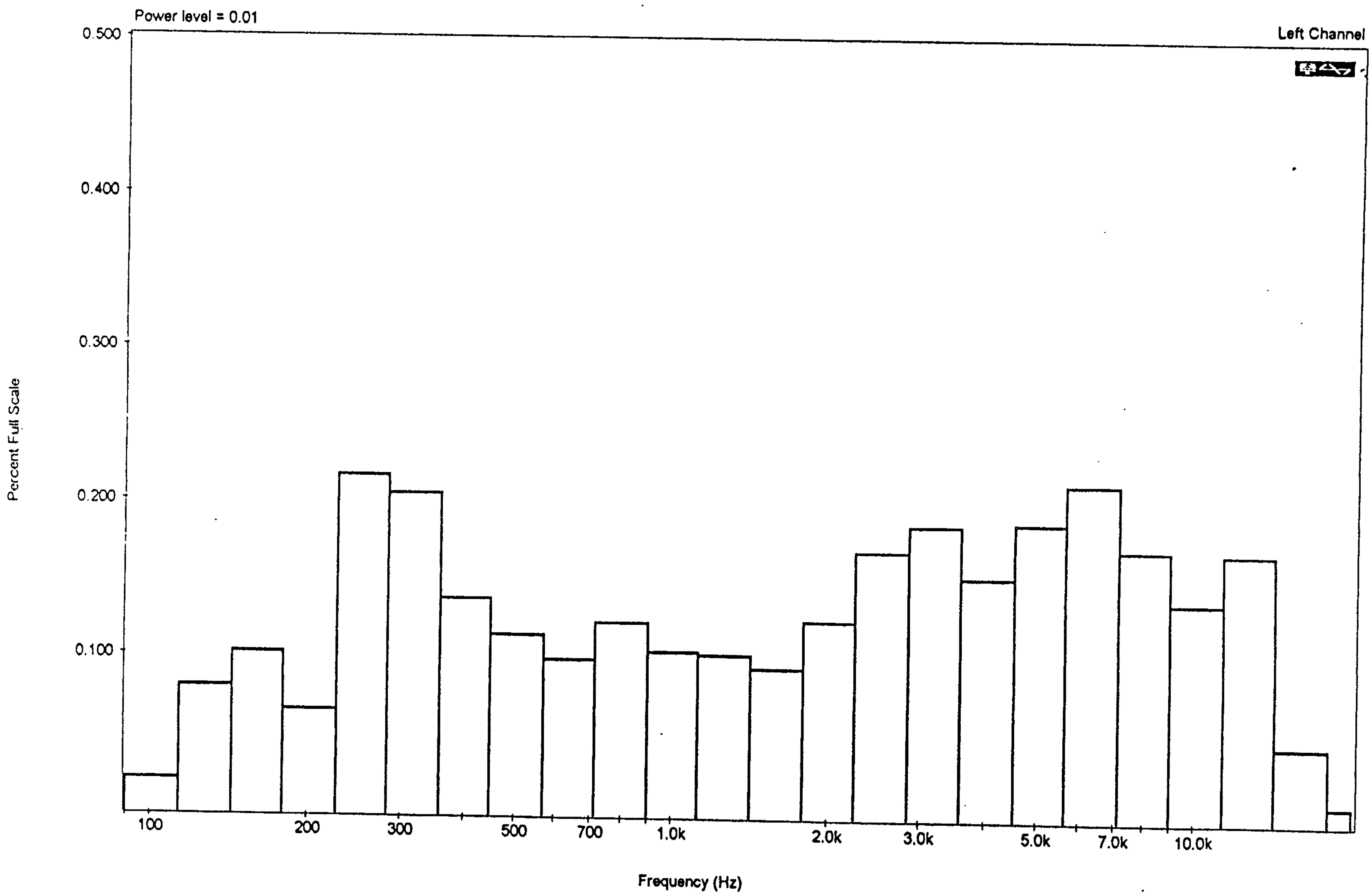

Recording of USAF's Light Decontamination Apparatus (LDA)

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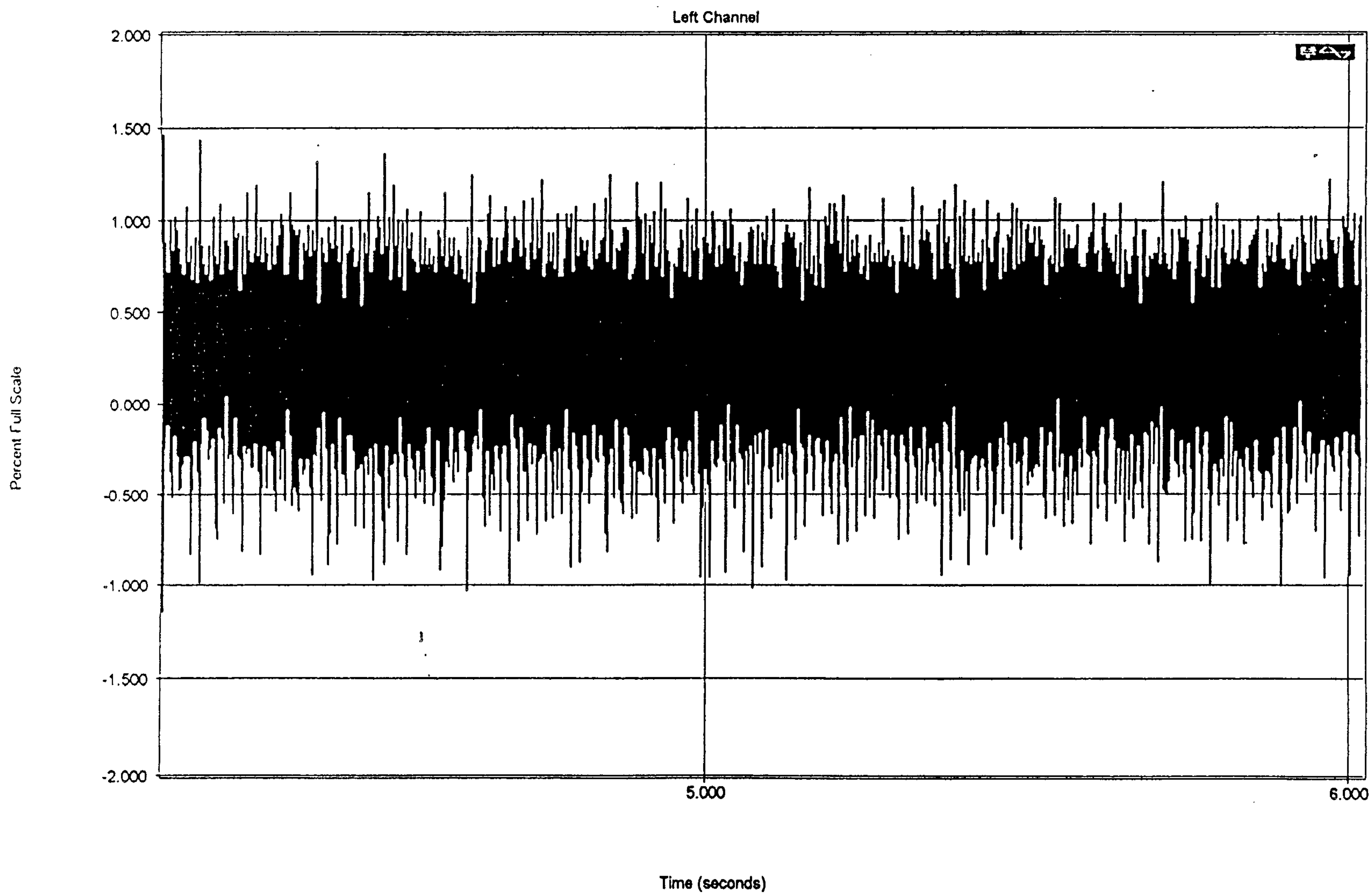

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Recording of USAF's Light Decontamination Apparatus (LDA)

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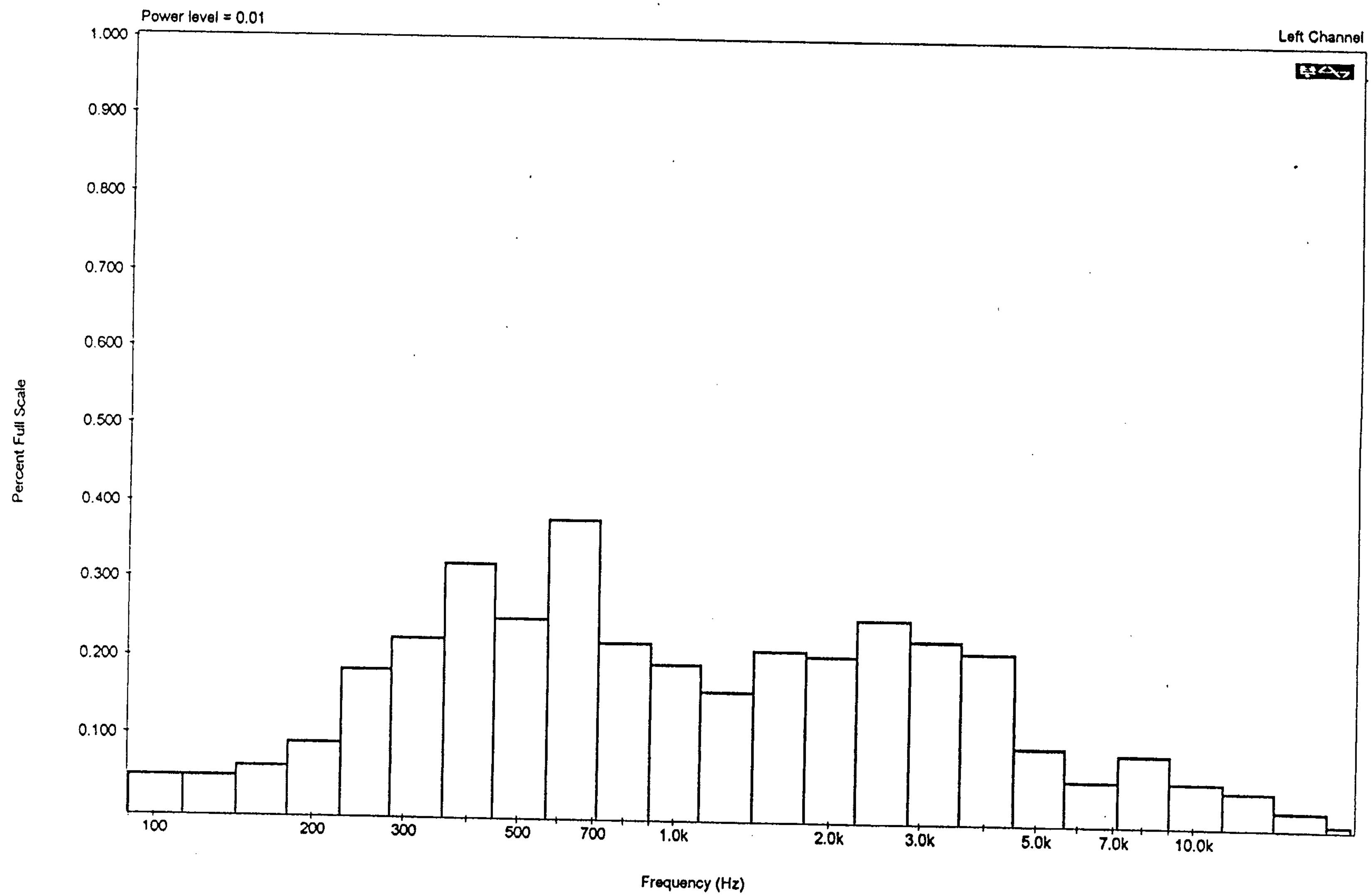

Appendix II
Modeling BRAC-Related Sound

Appendix II

Modeling BRAC-Related Sound

TABLE 1a. Modeled sound propagation (calculated sound level (dB) under different weather conditions) from mobile smoke training area, a proposed BRAC action at Fort Leonard Wood, Missouri. Twelve M56 generators: Peak SPL (maximum sound level) at source = 131 dB.

1. Summer-Overcast, Calm; Wind from SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	70	67	66	64
1000	33	34	45	51
1500	25	26	24	32
2000	21	21	16	14

2. Summer-Overcast, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	65	64	45	45
1000	36	33	33	33
1500	32	26	26	37
2000	21	20	20	21

3. Summer-Clear, Calm; Wind from NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	64	60	66	63
1000	37	49	33	47
1500	23	28	26	25
2000	23	21	21	17

4. Summer-Clear, Windy; Wind from S SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	65	63	54	59
1000	44	33	43	41
1500	21	24	30	28
2000	15	24	16	14

TABLE 1a (cont.). Modeled sound propagation from Mobile Smoke Training Area - Twelve M56 generators.

5. Winter-Overcast, Calm; Wind from N NE

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	57	56	56	55
1000	17	20	33	23
1500	21	26	26	26
2000	16	22	21	21

6. Winter-Overcast, Windy; Wind from SE

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	64	65	45	45
1000	39	36	33	33
1500	28	24	25	26
2000	22	13	20	21

7. Winter-Clear, Calm; Wind from S ground, NE above layers

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	54	56	58	45
1000	17	14	33	33
1500	27	18	25	26
2000	22	13	20	21

8. Winter-Clear, Windy; Wind from SW W

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	60	45	65	62
1000	32	33	33	32
1500	26	26	25	22
2000	20	20	21	16

TABLE 1b. Modeled sound propagation (calculated sound level (dB) under different weather conditions) from mobile smoke training area, a proposed BRAC action at Fort Leonard Wood, Missouri. Twelve M157 generators: Peak SPL (maximum sound level) at source = 121 dB

1. Summer-Overcast, Calm; Wind from SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	60	57	56	54
1000	23	24	35	41
1500	15	16	14	22
2000	11	11	15	12

2. Summer-Overcast, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	55	54	35	35
1000	26	23	23	23
1500	22	16	16	27
2000	23	10	10	11

3. Summer-Clear, Calm; Wind from NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	54	50	56	53
1000	27	39	23	37
1500	13	18	16	15
2000	13	20	11	14

4. Summer-Clear, Windy; Wind from S SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	55	53	44	59
1000	34	23	33	41
1500	19	14	20	28
2000	10	14	20	28

TABLE 1b (cont.). Modeled sound propagation from Mobile Smoke Training Area - Twelve M157 generators.

5. Winter-Overcast, Calm; Wind from N NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	47	46	46	45
1000	24	27	23	13
1500	22	16	16	16
2000	12	12	11	11

6. Winter-Overcast, Windy; Wind from SE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	54	55	35	35
1000	29	26	23	23
1500	18	14	15	16
2000	12	17	10	11

7. Winter-Clear, Calm; Wind from S ground, NE above layers

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	44	46	48	35
1000	25	22	23	23
1500	17	21	15	16
2000	12	10	10	11

8. Winter-Clear, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	50	35	55	52
1000	22	23	23	22
1500	16	16	15	23
2000	10	10	11	13

TABLE 1c. Modeled sound propagation (calculated sound level (dB) under different weather conditions) from decontamination training, a proposed BRAC action at Fort Leonard Wood, Missouri. Peak SPL (maximum sound level) at source = 107 dB

1. Summer-Overcast, Calm; Wind from SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	17	19	22	23
1000	9	9	17	22
1500	1	2	1	13
2000	0	0	9	8

2. Summer-Overcast, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	31	31	31	31
1000	24	24	24	24
1500	23	23	24	23
2000	25	25	26	26

3. Summer-Clear, Calm; Wind from NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	21	22	19	22
1000	13	15	8	13
1500	13	15	2	15
2000	12	10	0	8

4. Summer-Clear, Windy; Wind from S SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	25	23	20	21
1000	20	9	19	17
1500	8	13	15	13
2000	14	11	15	13

TABLE 1c (cont.). Modeled sound propagation from decontamination training.

5. Winter-Overcast, Calm; Wind from N NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	13	13	23	24
1000	21	13	8	18
1500	15	15	2	2
2000	10	14	0	0

6. Winter-Overcast, Windy; Wind from SE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	26	22	19	22
1000	15	10	9	10
1500	13	3	1	3
2000	10	0	0	0

7. Winter-Clear, Calm; Wind from S ground, NE above layers

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	22	23	24	15
1000	23	20	8	8
1500	16	14	2	2
2000	17	11	0	0

8. Winter-Clear, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	15	19	16	18
1000	9	9	19	31
1500	2	2	2	15
2000	0	0	0	10

TABLE 1d. Modeled sound propagation (calculated sound level (dB) under different weather conditions) from MOUT training, a proposed BRAC action at Fort Leonard Wood, Missouri. Peak SPL (maximum sound level) at source = 120 dB.

1. Summer-Overcast, Calm; Wind from SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	59	56	55	53
1000	22	23	34	40
1500	14	15	13	21
2000	10	10	14	11

2. Summer-Overcast, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	54	53	34	34
1000	25	22	22	22
1500	21	15	15	26
2000	22	9	9	10

3. Summer-Clear, Calm; Wind from NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	53	49	55	52
1000	26	38	22	36
1500	12	17	15	14
2000	12	19	10	13

4. Summer-Clear, Windy; Wind from S SW

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	54	52	43	48
1000	33	22	32	30
1500	18	13	19	17
2000	9	13	19	17

TABLE 1d (cont.). Modeled sound propagation from MOUT training.

5. Winter-Overcast, Calm; Wind from N NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	46	45	45	44
1000	23	26	22	12
1500	21	15	15	15
2000	11	21	10	10

6. Winter-Overcast, Windy; Wind from SE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	53	54	34	34
1000	28	25	22	22
1500	17	13	14	16
2000	11	16	9	10

7. Winter-Clear, Calm; Wind from S ground, NE above layers

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	43	45	47	34
1000	24	21	22	22
1500	16	20	14	15
2000	23	14	9	10

8. Winter-Clear, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	49	34	54	51
1000	21	22	22	21
1500	15	15	14	22
2000	9	9	10	12

TABLE 1e. Modeled sound propagation (calculated sound level (dB) under different weather conditions) from Air Force Base Recovery training, a proposed BRAC action at Fort Leonard Wood, Missouri. Peak SPL (maximum sound level) at source = 129 dB.

1. Summer-Overcast, Calm; Wind from SW

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	68	65	64	62
1000	31	32	43	49
1500	23	24	22	30
2000	19	19	14	12

2. Summer-Overcast, Windy; Wind from SW W

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	63	62	43	43
1000	34	31	31	31
1500	30	24	24	35
2000	19	18	18	19

3. Summer-Clear, Calm; Wind from NE

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	62	58	64	61
1000	35	47	31	45
1500	21	26	24	23
2000	21	19	19	15

4. Summer-Clear, Windy; Wind from S SW

Distance (m)	Predicted Sound Level in Each Direction			
from Source	North	East	South	West
500	63	61	52	57
1000	42	31	41	39
1500	19	22	28	26
2000	13	22	14	26

TABLE 1e (cont.). Modeled sound propagation from Air Force Base Recovery training.

5. Winter-Overcast, Calm; Wind from N NE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	55	54	54	53
1000	15	18	31	21
1500	19	24	24	24
2000	14	20	19	19

6. Winter-Overcast, Windy; Wind from SE

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	62	63	43	43
1000	37	34	31	31
1500	26	22	23	24
2000	20	25	18	19

7. Winter-Clear, Calm; Wind from S ground, NE above layers

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	52	54	56	43
1000	15	30	31	31
1500	25	16	23	24
2000	20	18	18	19

8. Winter-Clear, Windy; Wind from SW W

Distance (m) from Source	Predicted Sound Level in Each Direction			
	North	East	South	West
500	58	43	63	60
1000	30	31	31	30
1500	24	24	23	20
2000	18	18	19	14

Appendix III
Modeling Sound Propagation (ASOPRAT) for MOUT Training, Frequencies 25 - 4000 Hz

Appendix III

Modeling Sound Propagation (ASOPRAT) for MOUT Training, Frequencies 25 - 4000 Hz

Northern Sound Propagation Loss for an Overcast, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smroc.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	296.00	74.64	0.97	1.5	3.7
2	112.0	296.00	74.64	1.00	1.5	3.7
1	0.0	296.00	86.44	0.96	0.0	0.0

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7865	-27.9390	-28.3475	-29.1857	-30.9563	-34.6315	-41.1890	-51.6399	-54.0346
	-50.7807	-47.1300	-43.7936	-40.8594	-38.4854	-36.3215	-34.3656	-32.7802	-31.3611
	-30.0029	-29.3954	-29.8153	-32.1082	-41.6051				

500	-54.7212	-58.8243	-63.7474	-58.5230	-57.2688	-57.1794	-57.1187	-57.1149	-57.1654
	-57.2619	-57.4152	-57.6455	-57.9694	-58.3491	-58.8051	-59.3175	-59.8186	-60.3514
	-61.0313	-61.8205	-62.9205	-64.6171	-67.3463				
Shadow Zone for Rhz =		1000							
	-55.7973	–59.4818	-68.6548	-81.2448	-87.8539	-96.0526	-103.9034	-107.9720	-105.4778
	-101.2865	-99.6408	-96.4490	-94.0902	-89.2259	-86.9476	-85.4094	-82.4378	-80.6456
	-77.8771	-76.3658	-74.5790	-79.7342	-73.6775				
Shadow Zone for Rhz =		1500							
	-61.5183	-68.1480	-81.7957	-87.9087	-95.1809	-104.2602	-112.1587	-114.0235	-113.8728
	-109.3674	-105.2765	-101.6877	-98.3170	-96.9688	-93.1870	-88.4556	-92.3750	-92.1911
	-84.0613	-83.5925	-96.0148	-78.0054	-80.5955				
Shadow Zone for Rhz =		2000							
	-66.6649	-76.3542	-86.9017	-93.8851	-99.1600	-109.7630	-115.9869	-117.8159	-120.7775
	-110.9169	-108.3984	-102.9916	-100.9879	-102.1206	-106.1992	-92.9569	-94.6089	-86.9119
	-92.7596	-81.9347	-87.5395	-80.2894	-82.7659				

Eastern Sound Propagation Loss for an Overcast, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smroc.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	296.00	74.64	0.97	1.5	3.7
2	112.0	296.00	74.64	1.00	1.5	3.7
1	0.0	296.00	86.44	0.96	0.0	0.0

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7753	-27.9280	-28.3365	-29.1746	-30.9438	-34.6131	-41.1483	-51.5404	-54.1607
	-50.8870	-47.1791	-43.8107	-40.8607	-38.4793	-36.3116	-34.3540	-32.7681	-31.3491
	-29.9915	-29.3864	-29.8114	-32.1159	-41.6811				

500	-45.5604	-46.6456	-49.7287	-55.9709	-61.4937	-62.6487	-63.3468	-63.7786	-64.0930
	-64.3125	-64.5232	-64.7685	-65.0741	-65.4096	-65.7904	-66.1827	-66.4936	-66.6565
	-66.6247	-66.6237	-66.8830	-67.3105	-68.6757				
1000	-56.5609	-61.2175	-70.3306	-74.1628	-75.2935	-76.4110	-77.3712	-78.2492	-79.1162
	-79.8206	-80.4887	-81.1969	-82.0015	-82.8484	-83.8223	-84.9080	-85.9140	-86.6335
	-86.9377	-87.5117	-89.1017	-90.9983	-95.2060				
1500	-66.1373	-73.3328	-75.6999	-76.4075	-77.5752	-79.0388	-80.6146	-82.3975	-84.6546
	-87.0340	-89.8740	-93.5618	-98.7853	-106.7560	-117.3946	-107.0182	-104.7452	-105.0107
	-104.2581	-102.8678	-104.5920	-107.7925	-114.3095				
2000	-71.4018	-73.9162	-74.8485	-75.9320	-77.2330	-78.7431	-80.3021	-82.0155	-84.1216
	-86.2586	-88.6620	-91.4483	-94.5337	-97.2405	-99.2895	-100.5008	-101.5807	-103.6702
	-106.9363	-108.4364	-111.4964	-117.9344	-127.6614				

Southern Sound Propagation Loss for an Overcast, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smroc.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	296.00	74.64	0.97	1.5	3.7
2	112.0	296.00	74.64	1.00	1.5	3.7
1	0.0	296.00	86.44	0.96	0.0	0.0

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7341	-27.8873	-28.2960	-29.1328	-30.8959	-34.5418	-40.9910	-51.1317	-54.5937
	-51.3160	-47.3994	-43.9110	-40.9009	-38.4909	-36.3072	-34.3412	-32.7516	-31.3296
	-29.9672	-29.3591	-29.7816	-32.0770	-41.6353				

Shadow Zone for Rhz = 500

-48.0441	-49.4451	-53.0842	-60.6430	-75.6969	-83.5744	-90.2941	-95.2638	-94.7358
-90.7057	-86.9262	-83.1423	-80.5088	-77.4739	-74.9301	-73.0720	-70.6739	-69.8928
-67.3041	-64.9114	-64.4937	-62.4383	-62.8114				

Shadow Zone for Rhz = 1000

-55.7654	-59.4440	-68.4610	-81.4692	-88.0175	-96.3215	-102.8820	-106.1005	-106.0687
-103.6285	-99.2568	-95.6355	-92.4280	-89.0097	-87.5231	-83.9860	-81.6347	-82.0522
-81.2486	-75.3994	-76.7340	-75.5190	-74.4404				

Shadow Zone for Rhz = 1500

-61.5593	-68.1445	-81.4870	-88.3107	-95.5306	-103.3776	-110.9631	-113.3428	-114.5787
-107.8107	-105.1151	-106.0816	-99.5561	-96.4065	-97.3366	-94.1325	-90.7652	-88.6606
-87.5917	-80.1902	-83.1794	-79.3778	-79.3245				

Shadow Zone for Rhz = 2000

-66.7449	-79.1568	-87.4468	-93.4388	-101.0626	-107.6140	-113.8033	-116.8282	-122.7483
-113.1207	-112.8150	-106.5001	-101.8084	-100.4449	-101.7687	-95.3425	-93.9308	-98.0918
-80.1902	-90.5447	-91.5006	-96.7619	-87.0854				

Western Sound Propagation Loss for an Overcast, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smroc.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	296.00	74.64	0.97	1.5	3.7
2	112.0	296.00	74.64	1.00	1.5	3.7
1	0.0	296.00	86.44	0.96	0.0	0.0

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7452	-27.8983	-28.3069	-29.1440	-30.9088	-34.5609	-41.0331	-51.2407	-54.4769
	-51.1984	-47.3405	-43.8850	-40.8912	-38.4888	-36.3094	-34.3456	-32.7569	-31.3356
	-29.9743	-29.3666	-29.7892	-32.0855	-41.6383				

500	-46.1020	-47.2297	-50.4157	-57.1445	-64.2925	-65.8419	-66.8168	-67.4265	-67.8596
	-68.1339	-68.3578	-68.5750	-68.8020	-69.0087	-69.1848	-69.2746	-69.2170	-68.9452
	-68.3775	-67.8531	-67.6086	-67.6475	-68.6599				
1000	-53.5362	-57.0334	-64.7485	-69.2024	-70.2482	-70.9680	-71.3801	-71.6694	-71.9437
	-72.2157	-72.5615	-73.0411	-73.6990	-74.4675	-75.3951	-76.4459	-77.4570	-78.4313
	-79.5206	-80.8517	-82.8400	-85.6371	-90.4767				
1500	-62.3662	-69.8139	-78.0559	-79.2491	-80.3481	-81.2509	-81.9630	-82.5811	-83.2011
	-83.7639	-84.3985	-85.2036	-86.2547	-87.4578	-88.9067	-90.5636	-92.1663	-93.6246
	-95.0744	-96.9584	-100.0595	-104.1432	-111.5539				
2000	-70.7823	-80.6012	-81.8737	-82.7308	-83.8840	-85.2955	-86.7789	-88.3971	-90.3291
	-92.1997	-94.1887	-96.3694	-98.7290	-100.9814	-103.3024	-105.6638	-107.7990	-109.3457
	-109.9198	-111.1642	-114.8725	-119.7059	-129.2913				

Northern Sound Propagation Loss for a Clear, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcc.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	301.00	41.71	1.00	3.0	0.3
2	155.0	301.00	41.71	1.00	3.0	0.3
1	0.0	300.00	44.75	0.96	1.5	0.9

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7207	-27.8711	-28.2734	-29.0977	-30.8352	-34.4281	-40.7799	-50.8234	-54.7859
	-51.5730	-47.5830	-44.0451	-41.0070	-38.5792	-36.3792	-34.3975	-32.7976	-31.3731
	-30.0104	-29.4028	-29.8417	-32.1268	-41.4267				

500	-46.2089	-47.5068	-50.8449	-57.2078	-62.5284	-63.7292	-64.4773	-64.9754	-65.3691
	-65.6612	-65.9424	-66.2516	-66.5994	-66.9403	-67.2932	-67.6462	-67.9440	-68.1220
	-68.1513	-68.3696	-69.1400	-70.3292	-73.0627				
1000	-58.6046	-63.8817	-71.2393	-72.5296	-73.5491	-74.9441	-76.4770	-78.2281	-80.4474
	-82.7651	-85.4688	-88.8172	-93.0505	-97.4257	-99.1537	-97.0903	-95.6203	-94.9255
	-93.2234	-92.1062	-93.7219	-96.6482	-103.0417				
1500	-66.2371	-69.5344	-70.8745	-71.9342	-73.2150	-74.7082	-76.2581	-77.9696	-80.0773
	-82.2058	-84.5626	-87.2080	-89.9737	-92.1802	-93.5571	-94.0259	-94.4392	-95.9387
	-98.7543	-100.2516	-103.5428	-110.6022	-121.5326				
2000	-68.1437	-69.5597	-70.7498	-71.9260	-73.2560	-74.7633	-76.3052	-77.9934	-80.0586
	-82.1277	-84.3925	-86.8932	-89.4826	-91.6518	-93.3842	-94.6275	-95.7946	-97.8972
	-101.7438	-105.1744	-110.3170	-120.5774	-136.0096				

Eastern Sound Propagation Loss for a Clear, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
Input\smrcc.wth
Input name of geometry file
Input\east.geo
Input name of frequency file
Input\mout.fr
Input name of ground file
Input\forgras.grd
Input name of variational file
Input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	301.00	41.71	1.00	3.0	0.3
2	155.0	301.00	41.71	1.00	3.0	0.3
1	0.0	300.00	44.75	0.96	1.5	0.9

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7490	-27.8990	-28.3011	-29.1262	-30.8677	-34.4759	-40.8840	-51.0974	-54.4953
	-51.2697	-47.4325	-43.9800	-40.9839	-38.5758	-36.3865	-34.4103	-32.8126	-31.3897
	-30.0294	-29.4224	-29.8600	-32.1447	-41.4189				

500	-46.6541	-47.8668	-51.1781	-58.2445	-67.1663	-69.3539	-70.7798	-71.7172	-72.4060
	-72.8237	-73.1042	-73.2745	-73.3146	-73.1984	-72.8906	-72.3675	-71.7184	-70.9309
	-69.9593	-69.2818	-69.1828	-69.8095	-71.9994				
1000	-52.3420	-55.4430	-62.7529	-67.2971	-68.2704	-68.9715	-69.3886	-69.7075	-70.0462
	-70.4031	-70.8498	-71.4286	-72.1448	-72.8925	-73.7114	-74.5929	-75.4723	-76.4531
	-77.8221	-79.6824	-82.5669	-87.0402	-94.5950				
1500	-59.7228	-65.9936	-73.9062	-75.2005	-76.1702	-76.7893	-77.1999	-77.5612	-78.0003
	-78.5029	-79.1565	-80.0185	-81.0962	-82.2300	-83.4831	-84.8491	-86.2296	-87.7792
	-89.9515	-92.9263	-97.5387	-104.6111	-116.4905				
2000	-67.3367	-77.0230	-81.4484	-82.7575	-83.7493	-84.5459	-85.1817	-85.7799	-86.4810
	-87.2306	-88.1586	-89.3490	-90.8175	-92.3565	-94.0624	-95.9366	-97.8336	-99.8948
	-102.6626	-106.5463	-112.7519	-122.0316	-137.8694				

Southern Sound Propagation Loss for a Clear, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcc.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	301.00	41.71	1.00	3.0	0.3
2	155.0	301.00	41.71	1.00	3.0	0.3
1	0.0	300.00	44.75	0.96	1.5	0.9

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7741	-27.9238	-28.3258	-29.1516	-30.8966	-34.5186	-40.9775	-51.3431	-54.2333
	-51.0092	-47.2994	-43.9209	-40.9618	-38.5713	-36.3917	-34.4205	-32.8250	-31.4037
	-30.0456	-29.4396	-29.8768	-32.1628	-41.4218				

500	-51.7926	-54.9756	-64.0191	-65.6568	-62.3378	-61.9782	-61.7234	-61.6313	-61.6539
	-61.7625	-61.9468	-62.2115	-62.5499	-62.9034	-63.2835	-63.6797	-64.0692	-64.5247
	-65.1869	-66.0322	-67.3094	-69.4011	-72.8875				
Shadow Zone for Rhz =		1000							
	-55.7505	-59.4645	-68.6398	-81.4738	-88.0718	-96.3724	-104.0342	-106.3021	-106.2401
	-103.1273	-99.2906	-95.7357	-92.4658	-89.9331	-87.4302	-85.2175	-83.3411	-81.3251
	-79.2092	-77.6339	-76.2325	-75.2825	-75.9552				
Shadow Zone for Rhz =		1500							
	-61.5386	-68.1764	-81.7945	-88.3574	-95.2496	-103.5633	-109.6490	-113.3713	-113.4848
	-110.0194	-106.1510	-102.7909	-99.5558	-96.8963	-94.4794	-92.2682	-90.4827	-88.3195
	-86.0164	-84.6741	-83.1384	-81.9861	-82.5570				
Shadow Zone for Rhz =		2000							
	-66.6620	-76.3532	-87.7847	-93.4248	-100.6612	-108.1071	-116.4141	-117.9650	-118.3420
	-115.2004	-111.1666	-107.6662	-104.5856	-101.9496	-99.4615	-97.2966	-95.5075	-93.2873
	-90.9214	-89.6461	-88.0106	-86.7010	-87.3906				

Western Sound Propagation Loss for a Clear, Calm Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcc.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	301.00	41.71	1.00	3.0	0.3
2	155.0	301.00	41.71	1.00	3.0	0.3
1	0.0	300.00	44.75	0.96	1.5	0.9

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7457	-27.8958	-28.2979	-29.1229	-30.8639	-34.4705	-40.8722	-51.0671	-54.5309
	-51.3034	-47.4482	-43.9860	-40.9850	-38.5747	-36.3842	-34.4074	-32.8097	-31.3867
	-30.0264	-29.4198	-29.8585	-32.1454	-41.4332				

500	-46.2022	-47.3272	-50.4925	-57.2156	-64.7664	-66.4339	-67.4935	-68.1725	-68.6746
	-69.0086	-69.2880	-69.5490	-69.7877	-69.9569	-70.0396	-69.9940	-69.8135	-69.4691
	-68.9288	-68.5790	-68.7313	-69.5237	-71.8426				
1000	-53.2157	-56.5705	-64.1092	-68.6660	-69.7022	-70.4329	-70.8683	-71.1983	-71.5427
	-71.9010	-72.3474	-72.9256	-73.6427	-74.3941	-75.2218	-76.1198	-77.0167	-77.9945
	-79.3218	-81.1593	-84.0609	-88.4766	-96.0190				
1500	-61.8180	-68.9498	-77.3990	-78.7114	-79.8243	-80.6771	-81.3261	-81.8997	-82.5197
	-83.1365	-83.8664	-84.7795	-85.8926	-87.0541	-88.3415	-89.7590	-91.1855	-92.6754
	-94.5700	-97.2972	-101.8123	-108.4351	-119.9779				
2000	-70.0759	-80.3169	-82.4007	-83.3208	-84.4722	-85.8431	-87.2587	-88.7751	-90.5462
	-92.2220	-93.9681	-95.8477	-97.8449	-99.7234	-101.6616	-103.7092	-105.7174	-107.5283
	-109.2033	-112.0222	-117.8084	-126.0781	-141.2063				

Northern Sound Propagation Loss for a Clear, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcw.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	305.00	31.38	0.97	4.1	3.5
2	87.0	305.00	31.44	1.00	4.1	3.5
1	0.0	301.00	52.10	0.96	2.6	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7394	-27.8882	-28.2872	-29.1065	-30.8357	-34.4177	-40.7733	-50.9042	-54.5933
	-51.4222	-47.5413	-44.0568	-41.0446	-38.6310	-36.4414	-34.4672	-32.8719	-31.4496
	-30.0810	-29.4538	-29.8598	-32.0650	-41.0327				

500	-45.6803	-46.7190	-49.7279	-56.0310	-62.3406	-63.6504	-64.4598	-64.9729	-65.3617
	-65.6447	-65.9188	-66.2266	-66.5801	-66.9279	-67.2740	-67.5797	-67.7835	-67.8493
	-67.7580	-67.7743	-68.1985	-69.1003	-71.3647				
1000	-54.9985	-58.9428	-67.2608	-72.0676	-73.2588	-74.1596	-74.7541	-75.2200	-75.6768
	-76.1071	-76.6113	-77.2537	-78.0626	-78.9340	-79.9176	-80.9906	-82.0224	-83.0060
	-84.0949	-85.6231	-88.2301	-91.9476	-98.6436				
1500	-64.3710	-72.5317	-78.6222	-79.2408	-80.3611	-81.7243	-83.1576	-84.7172	-86.5647
	-88.3275	-90.1624	-92.1134	-94.1377	-95.9774	-97.7860	-99.5768	-101.2110	-102.4208
	-102.8884	-104.1087	-107.8090	-112.9266	-122.9164				
2000	-72.2106	-77.7679	-78.2964	-79.2360	-80.5053	-82.0659	-83.7436	-85.6558	-88.1067
	-90.7183	-93.8349	-97.7815	-102.9207	-108.9059	-113.5190	-112.1486	-111.4513	-113.1036
	-115.1697	-115.4490	-119.5839	-127.4816	-140.9593				

Eastern Sound Propagation Loss for a Clear, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcw.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	305.00	31.38	0.97	4.1	3.5
2	87.0	305.00	31.44	1.00	4.1	3.5
1	0.0	301.00	52.10	0.96	2.6	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7165	-27.8656	-28.2649	-29.0835	-30.8097	-34.3797	-40.6910	-50.6881	-54.8260
	-51.6686	-47.6606	-44.1058	-41.0597	-38.6302	-36.4321	-34.4537	-32.8568	-31.4335
	-30.0638	-29.4373	-29.8464	-32.0572	-41.0686				

500	-46.4687	-47.8431	-51.2802	-57.7313	-63.0712	-64.3009	-65.0836	-65.6183	-66.0472
	-66.3651	-66.6700	-67.0085	-67.3999	-67.7975	-68.2219	-68.6518	-69.0091	-69.2089
	-69.1893	-69.3201	-69.9904	-70.9730	-73.4025				
1000	-58.9702	-64.1771	-70.5122	-71.5981	-72.6439	-74.0500	-75.5915	-77.3553	-79.6065
	-81.9918	-84.8482	-88.5773	-93.9819	-103.1708	-108.4408	-98.6835	-96.1350	-95.6555
	-94.3330	-92.8489	-94.1381	-96.8710	-102.6621				
1500	-65.8640	-68.5982	-69.9230	-71.0216	-72.3082	-73.7899	-75.3166	-76.9930	-79.0470
	-81.1124	-83.3927	-85.9496	-88.6349	-90.8411	-92.3973	-93.2062	-93.8928	-95.5123
	-98.4290	-100.1084	-103.1987	-109.9752	-120.1330				
2000	-67.4682	-68.7782	-69.9628	-71.1298	-72.4438	-73.9297	-75.4479	-77.1092	-79.1430
	-81.1879	-83.4445	-85.9751	-88.6662	-91.0172	-93.0219	-94.5830	-95.9978	-98.2301
	-102.0752	-105.4225	-110.2302	-119.8638	-134.1721				

Southern Sound Propagation Loss for a Clear, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcw.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0   RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0   BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	305.00	31.38	0.97	4.1	3.5
2	87.0	305.00	31.44	1.00	4.1	3.5
1	0.0	301.00	52.10	0.96	2.6	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.6677	-27.8175	-28.2171	-29.0345	-30.7541	-34.2980	-40.5148	-50.2208	-55.2862
	-52.2290	-47.9316	-44.2218	-41.1020	-38.6384	-36.4217	-34.4339	-32.8330	-31.4070
	-30.0326	-29.4042	-29.8139	-32.0213	-41.0537				

500	-49.1569	-51.4588	-56.1329	-62.5951	-65.2577	-66.5302	-67.9676	-69.5981	-71.6388
	-73.7209	-76.0493	-78.6706	-81.2046	-82.4063	-81.8389	-80.3966	-79.2154	-78.1263
	-76.1821	-74.5793	-74.5003	-74.7788	-76.7521				
1000	-59.4023	-61.4210	-63.0024	-64.1629	-65.3992	-66.7866	-68.1947	-69.7179	-71.5455
	-73.3317	-75.2366	-77.2814	-79.3159	-80.8854	-81.8992	-82.3088	-82.6216	-83.6917
	-85.7810	-86.7093	-88.4775	-93.0029	-99.4878				
1500	-61.9931	-62.9297	-63.9344	-64.9474	-66.0988	-67.4123	-68.7612	-70.2362	-72.0271
	-73.7998	-75.7155	-77.8108	-79.9778	-81.8183	-83.3365	-84.4588	-85.4522	-87.1258
	-90.1329	-92.6347	-96.1024	-103.4588	-114.1020				
2000	-63.5371	-64.2275	-65.0484	-65.9292	-66.9710	-68.1992	-69.4972	-70.9554	-72.7767
	-74.6324	-76.6957	-79.0229	-81.5226	-83.7602	-85.7703	-87.4624	-89.0125	-91.2584
	-95.0522	-98.6923	-103.7190	-113.4967	-128.0614				

Western Sound Propagation Loss for a Clear, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrcw.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	305.00	31.38	0.97	4.1	3.5
2	87.0	305.00	31.44	1.00	4.1	3.5
1	0.0	301.00	52.10	0.96	2.6	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.6904	-27.8398	-28.2392	-29.0572	-30.7798	-34.3358	-40.5962	-50.4366	-55.0782
	-51.9642	-47.8049	-44.1679	-41.0823	-38.6346	-36.4264	-34.4430	-32.8439	-31.4192
	-30.0469	-29.4195	-29.8290	-32.0382	-41.0621				

500	-48.1372	-50.0944	-54.3825	-61.5047	-65.8834	-67.1848	-68.3872	-69.5383	-70.7276
	-71.6938	-72.5350	-73.2669	-73.8737	-74.3006	-74.6001	-74.7781	-74.8263	-74.5470
	-73.6105	-72.8996	-73.1558	-73.6351	-75.7534				
1000	-59.9039	-63.1792	-65.5249	-66.6567	-67.8788	-69.2978	-70.7647	-72.3744	-74.3382
	-76.2991	-78.4474	-80.8347	-83.2938	-85.1780	-86.1979	-86.3054	-86.3544	-87.3330
	-89.1517	-89.4177	-90.9575	-94.9773	-101.1701				
1500	-63.3444	-64.6245	-65.7965	-66.9120	-68.1564	-69.5587	-70.9852	-72.5345	-74.4072
	-76.2569	-78.2553	-80.4412	-82.6958	-84.5883	-86.1031	-87.1652	-88.0988	-89.7659
	-92.7802	-95.1318	-98.5079	-105.7688	-116.2957				
2000	-64.6774	-65.5651	-66.5565	-67.5785	-68.7524	-70.1020	-71.4997	-73.0445	-74.9488
	-76.8699	-78.9916	-81.3720	-83.9149	-86.1731	-88.1746	-89.8280	-91.3384	-93.5793
	-97.3932	-100.9615	-105.9178	-115.6691	-130.1534				

Northern Sound Propagation Loss for an Overcast, Windy Summer Day - 25 - 4000Hz

Input name of weather file
input\smrow.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	288.00	92.71	0.97	2.5	4.5
2	121.0	288.00	92.71	1.00	2.5	4.5
1	0.0	290.00	92.78	0.96	5.0	3.8

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7187	-27.8790	-28.3025	-29.1659	-30.9795	-34.7166	-41.2839	-51.3475	-54.6673
	-51.2875	-47.2974	-43.7875	-40.7703	-38.3544	-36.1627	-34.1873	-32.5874	-31.1554
	-29.8066	-29.2500	-29.7456	-32.2573	-42.7829				

500	-51.9911	-55.3275	-65.1792	-65.0692	-61.9596	-61.6113	-61.3608	-61.2553	-61.2463
	-61.3133	-61.4484	-61.6649	-61.9749	-62.3384	-62.7703	-63.2458	-63.6979	-64.1653
	-64.7347	-65.3552	-66.2102	-67.5520	-69.7538				
Shadow Zone for Rhz =		1000							
	-55.7729	-59.4306	-68.6601	-81.3271	-87.9387	-96.5854	-102.5814	-106.4353	-104.9320
	-101.3031	-100.6055	-95.3509	-91.6367	-90.8891	-87.4115	-87.5798	-82.7339	-78.8421
	-80.9039	-80.1960	-72.5347	-72.5634	-76.1649				
Shadow Zone for Rhz =		1500							
	-61.5332	-68.0938	-81.6584	-87.9283	-95.9589	-104.0049	-111.3822	-113.3634	-113.5157
	-109.1387	-107.7086	-99.7096	-95.7912	-95.7238	-91.6600	-90.0835	-85.2478	-84.8203
	-95.3626	-98.3727	-80.3289	-94.7901	-76.7597				
Shadow Zone for Rhz =		2000							
	-66.7280	-76.4469	-86.8655	-94.0006	-99.8518	-110.7983	-115.9988	-116.2530	-120.6259
	-111.0632	-112.0980	-101.5441	-98.9853	-96.7431	-96.4498	-91.5705	-97.3988	-101.6997
	-84.8144	-81.9707	-86.7384	-78.8503	-92.2882				

Eastern Sound Propagation Loss for an Overcast, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrow.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	288.00	92.71	0.97	2.5	4.5
2	121.0	288.00	92.71	1.00	2.5	4.5
1	0.0	290.00	92.78	0.96	5.0	3.8

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7683	-27.9279	-28.3512	-29.2161	-31.0370	-34.8032	-41.4780	-51.8236	-54.1209
	-50.7844	-47.0507	-43.6820	-40.7345	-38.3516	-36.1779	-34.2116	-32.6154	-31.1862
	-29.8411	-29.2844	-29.7769	-32.2840	-42.7254				

500	-49.9910	-52.3285	-57.9944	-67.3392	-67.9358	-67.0269	-66.4048	-66.1160	-66.0052
	-66.0181	-66.1042	-66.2498	-66.4374	-66.6191	-66.7826	-66.9005	-66.9650	-67.0083
	-67.0361	-67.0820	-67.3668	-68.1527	-69.9652				
Shadow Zone for Rhz =		1000							
	-55.9655	-59.8852	-69.4864	-82.1523	-88.5688	-96.8767	-103.4923	-106.4395	-105.3804
	-103.6708	-98.6946	-95.0073	-92.2803	-88.3560	-86.0722	-83.9577	-83.5140	-83.0746
	-77.6870	-76.4428	-75.5157	-74.0412	-75.0640				
Shadow Zone for Rhz =		1500							
	-61.9075	-68.9824	-82.4728	-89.1731	-95.6891	-103.8410	-110.2612	-114.5727	-112.2683
	-108.9073	-104.6763	-100.8359	-102.7661	-96.2450	-95.5312	-92.8662	-94.9270	-87.2545
	-86.0788	-84.3733	-80.9778	-87.7316	-77.9078				
Shadow Zone for Rhz =		2000							
	-67.2764	-77.4198	-87.8601	-94.5127	-101.3395	-107.8500	-114.2977	-117.4006	-119.9282
	-116.4154	-115.9129	-105.7048	-103.5709	-102.4816	-103.0737	-95.9503	-91.0973	-89.6995
	-88.7926	-84.7426	-84.4984	-81.8461	-89.3059				

Southern Sound Propagation Loss for an Overcast, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrow.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	288.00	92.71	0.97	2.5	4.5
2	121.0	288.00	92.71	1.00	2.5	4.5
1	0.0	290.00	92.78	0.96	5.0	3.8

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8471	-28.0057	-28.4289	-29.2963	-31.1293	-34.9426	-41.7937	-52.5711	-53.2535
	-50.0432	-46.6671	-43.5107	-40.6730	-38.3432	-36.1990	-34.2479	-32.6583	-31.2338
	-29.8951	-29.3392	-29.8281	-32.3306	-42.6518				

Shadow Zone for Rhz =	500							
-48.0441	-49.4451	-53.0842	-60.6430	-75.6969	-83.5744	-90.2941	-95.2638	-94.7358
-90.7057	-86.9262	-83.1423	-80.5088	-77.4739	-74.9301	-73.0720	-70.6739	-69.8928
-67.3041	-64.9114	-64.4937	-62.4383	-62.8114				
Shadow Zone for Rhz =	1000							
-55.7654	-59.4440	-68.4610	-81.4692	-88.0175	-96.3215	-102.8820	-106.1005	-106.0687
-103.6285	-99.2568	-95.6355	-92.4280	-89.0097	-87.5231	-83.9860	-81.6347	-82.0522
-81.2486	-75.3994	-76.7340	-75.5190	-74.4404				
Shadow Zone for Rhz =	1500							
-61.5593	-68.1445	-81.4870	-88.3107	-95.5306	-103.3776	-110.9631	-113.3428	-114.5787
-107.8107	-105.1151	-106.0816	-99.5561	-96.4065	-97.3366	-94.1325	-90.7652	-88.6606
-87.5917	-80.1902	-83.1794	-79.3778	-79.3245				
Shadow Zone for Rhz =	2000							
-66.7449	-79.1568	-87.4468	-93.4388	-101.0626	-107.6140	-113.8033	-116.8282	-122.7483
-113.1207	-112.8150	-106.5001	-101.8084	-100.4449	-101.7687	-95.3425	-93.9308	-98.0918
-80.1902	-90.5447	-91.5006	-96.7619	-87.0854				

Western Sound Propagation Loss for an Overcast, Windy Summer Day - Frequencies 25 - 4000Hz

Input name of weather file
input\smrow.wth
Input name of weather file
input\smrow.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0   RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0   BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	437.0	288.00	92.71	0.97	2.5	4.5
2	121.0	288.00	92.71	1.00	2.5	4.5
1	0.0	290.00	92.78	0.96	5.0	3.8

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8471	-28.0057	-28.4289	-29.2963	-31.1293	-34.9426	-41.7937	-52.5711	-53.2535
	-50.0432	-46.6671	-43.5107	-40.6730	-38.3432	-36.1990	-34.2479	-32.6583	-31.2338
	-29.8951	-29.3392	-29.8281	-32.3306	-42.6518				

Shadow Zone for Rhz = 500

-48.0441	-49.4451	-53.0842	-60.6430	-75.6969	-83.5744	-90.2941	-95.2638	-94.7358
-90.7057	-86.9262	-83.1423	-80.5088	-77.4739	-74.9301	-73.0720	-70.6739	-69.8928
-67.3041	-64.9114	-64.4937	-62.4383	-62.8114				

Shadow Zone for Rhz = 1000

-55.7654	-59.4440	-68.4610	-81.4692	-88.0175	-96.3215	-102.8820	-106.1005	-106.0687
-103.6285	-99.2568	-95.6355	-92.4280	-89.0097	-87.5231	-83.9860	-81.6347	-82.0522
-81.2486	-75.3994	-76.7340	-75.5190	-74.4404				

Shadow Zone for Rhz = 1500

-61.5593	-68.1445	-81.4870	-88.3107	-95.5306	-103.3776	-110.9631	-113.3428	-114.5787
-107.8107	-105.1151	-106.0816	-99.5561	-96.4065	-97.3366	-94.1325	-90.7652	-88.6606
-87.5917	-80.1902	-83.1794	-79.3778	-79.3245				

Shadow Zone for Rhz = 2000

-66.7449	-79.1568	-87.4468	-93.4388	-101.0626	-107.6140	-113.8033	-116.8282	-122.7483
-113.1207	-112.8150	-106.5001	-101.8084	-100.4449	-101.7687	-95.3425	-93.9308	-98.0918
-80.1902	-90.5447	-91.5006	-96.7619	-87.0854				

Northern Sound Propagation Loss for a Clear, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcw.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	279.00	78.54	0.97	4.6	4.4
2	187.0	279.00	78.54	0.98	4.6	4.4
1	0.0	283.00	44.83	1.00	2.1	3.7

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	150.0	4000.0				
X(m)									
50	-27.7858	-27.9546	-28.3977	-29.2994	-31.1930	-35.1024	-42.0158	-52.4067	-53.7887
	-50.4041	-46.7563	-43.4518	-40.5387	-38.1724	-36.0117	-34.0629	-32.4906	-31.1004
	-29.8558	-29.4690	-30.2066	-33.2350	-45.3328				

500	-53.6150	-58.2009	-82.0715	-61.2136	-59.4989	-59.3133	-59.1985	-59.1705	-59.2007
	-59.2616	-59.3419	-59.4405	-59.5632	-59.7110	-59.9242	-60.2551	-60.7322	-61.4701
	-62.7651	-64.6088	-67.4561	-72.0202	-79.3410				
Shadow Zone for Rhz =		1000							
	-55.9794	-60.2266	-70.2406	-82.1721	-89.0038	-96.9499	-104.4367	-107.4174	-106.0277
	-102.3926	-98.4244	-94.8451	-92.0057	-89.5647	-87.0060	-84.8557	-82.8291	-80.9678
	-79.0589	-77.2677	-75.8564	-75.8640	-77.5968				
Shadow Zone for Rhz =		1500							
	-61.9381	-69.2435	-82.8642	-89.2707	-96.5180	-104.1835	-111.7661	-114.9449	-113.3553
	-109.3852	-1052365	-102.1767	-98.9243	-96.1993	-94.4287	-91.7663	-89.7266	-87.8706
	-86.0548	-84.5563	-82.4768	-82.5670	-84.4939				
Shadow Zone for Rhz =		2000							
	-67.2602	-77.8202	-88.0302	-94.3311	-101.5072	-109.2100	-116.9203	-119.3422	-118.3874
	-114.6581	-110.4037	-107.4183	-104.3142	-101.4292	-99.5944	-96.5611	-94.9484	-93.0958
	-90.8531	-89.4853	-87.5813	-87.4623	-89.4862				

Eastern Sound Propagation Loss for a Clear, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcw.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	279.00	78.54	0.97	4.6	4.4
2	187.0	279.00	78.54	0.98	4.6	4.4
1	0.0	283.00	44.83	1.00	2.1	3.7

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8295	-27.9977	-28.4408	-29.3439	-31.2446	-35.1817	-42.1996	-52.7987	-53.2961
	-50.0085	-46.5555	-43.3642	-40.5096	-38.1715	-36.0264	-34.0856	-32.5167	-31.1289
	-29.8872	-29.4996	-30.2334	-33.2538	-45.2295				

Shadow Zone for Rhz =	500							
-48.1099	-49.5846	-53.5007	-62.1036	-76.4493	-84.2417	-91.1658	-94.6295	-93.9015
-90.2724	-86.3381	-83.1665	-79.8783	-77.4991	-74.9457	-72.6096	-70.7590	-68.8742
-67.0150	-65.4334	-64.5052	-64.6857	-66.3106				
Shadow Zone for Rhz =	1000							
-55.9387	-60.0794	-69.9292	-82.2321	-88.8118	-96.6875	-104.3380	-107.4826	-105.8644
-102.2892	-98.5620	-95.1075	-92.0882	-89.4832	-86.9121	-84.6199	-83.1790	-80.6495
-78.6709	-77.3941	-75.8613	-75.8971	-77.7061				
Shadow Zone for Rhz =	1500							
-61.8647	-68.9715	-82.7898	-89.1326	-95.9924	-104.2963	-110.2395	-113.4953	-113.0662
-109.6530	-105.5186	-101.9086	-99.1062	-96.6933	-94.2633	-91.3499	-90.3992	-88.0057
-85.9060	-83.9950	-82.5489	-82.8486	-84.3406				
Shadow Zone for Rhz =	2000							
-67.1613	-77.5310	-88.0941	-94.3986	-100.8299	-108.9226	-116.9079	-119.7330	-118.2917
-114.2692	-110.2189	-107.4068	-104.3583	-101.9171	-98.8938	-96.2811	-95.2669	-92.5457
-91.1086	-89.1715	-86.8255	-87.3670	-89.1771				

Southern Sound Propagation Loss for a Clear, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcw.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0　　RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0　　BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	279.00	78.54	0.97	4.6	4.4
2	187.0	279.00	78.54	0.98	4.6	4.4
1	0.0	283.00	44.83	1.00	2.1	3.7

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7917	-27.9604	-28.4036	-29.3054	-31.2000	-35.1131	-42.0405	-52.4608	-53.7214
	-50.3493	-46.7288	-43.4399	-40.5348	-38.1722	-36.0136	-34.0659	-32.4941	-31.1042
	-29.8600	-29.4731	-30.2102	-33.2377	-45.3196				

500	-54.9993	-59.3344	-62.9751	-58.1294	-57.1941	-57.1207	-57.0844	-57.0993	-57.1551
	-57.2287	-57.3168	-57.4208	-57.5483	-57.7010	-57.9210	-58.2620	-58.7519	-59.5065
	-60.8303	-62.7204	-65.6364	-70.3054	-77.7938				
Shadow Zone for Rhz =		1000							
	-55.9581	-59.9855	-69.7073	-81.9483	-88.5436	-96.9287	-103.3562	-107.8262	-106.4079
	-102.7002	-98.5740	-95.1414	-92.0945	-89.5522	-87.1688	-84.9201	-82.6091	-81.0943
	-79.0028	-77.3227	-76.0621	-75.9290	-77.3551]				
Shadow Zone for Rhz =		1500							
	-61.8704	-68.8164	-82.6338	-88.8159	-95.7203	-104.0665	-111.2212	-114.9015	-113.3813
	-109.8589	-105.7577	-101.9785	-99.4296	-96.5301	-94.4197	-91.9215	-89.8656	-87.6872
	-85.8278	-84.5649	-83.0501	-82.3926	-83.9984				
Shadow Zone for Rhz =		2000							
	-67.1238	-77.1191	-88.0611	-93.8449	-100.7308	-108.6814	-114.8035	-119.1970	-117.9201
	-114.3096	-110.4944	-106.7904	-103.9483	-101.5814	-98.6962	-97.4329	-95.0532	-92.9271
	-91.3164	-89.1764	-87.9474	-87.4140	-89.0313				

Western Sound Propagation Loss for a Clear, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
Input\wtrcw.wth
Input name of geometry file
Input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	279.00	78.54	0.97	4.6	4.4
2	187.0	279.00	78.54	0.98	4.6	4.4
1	0.0	283.00	44.83	1.00	2.1	3.7

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7483	-27.9175	-28.3608	-29.2612	-31.1488	-35.0344	-41.8594	-52.0571	-54.2168
	-50.7620	-46.9338	-43.5287	-40.5651	-38.1746	-36.0006	-34.0450	-32.4698	-31.0773
	-29.8298	-29.4431	-30.1824	-33.2142	-45.3973				

500	-45.9415	-47.1543	-50.5586	-57.5298	-63.5584	-64.9134	-65.7682	-66.3049	-66.6817
	-66.9030	-67.0502	-67.1466	-67.2013	-67.2224	-67.2274	-67.2358	-67.2648	-67.3174
	-67.5278	-68.2437	-69.9154	-72.9948	-78.8284				
1000	-54.3871	-58.3942	-66.7054	-70.5842	-71.6974	-72.4692	-72.9418	-73.2846	-73.5849
	-73.8207	-74.0417	-74.2723	-74.5398	-74.8569	-75.3168	-76.0280	-77.0062	-78.3752
	-80.6692	-84.1500	-89.6952	-98.2898	-112.5091				
1500	-63.8123	-72.2033	-79.0010	-79.9546	-81.0907	-82.2542	-83.3269	-84.3459	-85.3649
	-86.1636	-86.8463	-87.4590	-88.0523	-88.6553	-89.4532	-90.6351	-92.1902	-94.1295
	-97.1197	-102.0236	-110.3806	-122.9359	-144.3505				
2000	-72.5363	-80.1350	-80.4958	-81.4162	-82.6861	-84.2642	-85.9531	-87.8373	-90.1467
	-92.4481	-94.9896	-97.9689	-101.6044	-105.6414	-109.5121	-110.3952	-110.5503	-111.5883
	-112.6350	-116.8637	-127.4657	-143.7541	-172.2804				

Northern Sound Propagation Loss for an Overcast, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtroc.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	91.68	0.99	2.5	0.5
2	254.0	267.00	91.68	1.00	2.5	0.5
1	0.0	267.00	91.68	0.97	1.0	0.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7547	-27.9434	-28.4285	-29.4050	-31.4399	-35.6024	-42.8245	-52.7553	-53.8053
	-50.2733	-46.5180	-43.1864	-40.2785	-37.9298	-35.7971	-33.8868	-32.3538	-31.0138
	-29.9011	-29.7295	-30.7360	-34.4051	-49.1092				

500	-45.9997	-47.3568	-51.0945	-58.4847	-63.7469	-65.0478	-65.8473	-66.3352	-66.6584
	-66.8328	-66.9415	-67.0162	-67.0786	-67.1455	-67.2523	-67.4480	-67.7588	-68.2502
	-69.2370	-71.0020	-74.0415	-78.8250	-86.2449				
1000	-54.6050	-58.9623	-67.5155	-70.6511	-71.7318	-72.4465	-72.8645	-73.1414	-73.3547
	-73.5092	-73.6638	-73.8628	-74.1611	-74.5896	-75.2813	-76.4069	-77.9996	-80.3114
	-84.2277	-89.8459	-98.1506	-110.1898	-127.5733]				
1500	-64.3575	-73.2733	-79.0580	-80.0546	-81.1743	-82.3033	-83.3121	-84.2313	-85.1058
	-85.7650	-86.3307	-86.8803	-87.5076	-88.2691	-89.4068	-91.1960	-93.6353	-96.9330
	-102.3544	-110.5100	-122.9731	-140.6865	-166.8399				
2000	-73.4144	-80.3266	-80.6086	-81.5639	-82.8458	-84.4092	-86.0497	-87.8471	-90.0248
	-92.2029	-94.6602	-97.6441	-101.4254	-105.6588	-109.3296	-110.3184	-111.5959	-114.2041
	-118.6109	-127.4826	-143.7027	-166.7488	-201.6828				

Eastern Sound Propagation Loss for an Overcast, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtroc.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	91.68	0.99	2.5	0.5
2	254.0	267.00	91.68	1.00	2.5	0.5
1	0.0	267.00	91.68	0.97	1.0	0.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7599	-27.9487	-28.4339	-29.4107	-31.4469	-35.6138	-42.8522	-52.8141	-53.7472
	-50.2172	-46.4841	-43.1659	-40.2651	-37.9201	-35.7898	-33.8809	-32.3490	-31.0105
	-29.9005	-29.7326	-30.7459	-34.4337	-49.2016				

500	-46.6313	-48.1065	-52.0530	-60.0970	-66.9244	-68.7282	-69.8860	-70.6193	-71.1114
	-71.3559	-71.4588	-71.4447	-71.3182	-71.1104	-70.8295	-70.5286	-70.3233	-70.2919
	-70.7314	-72.0608	-74.7663	-79.3069	-86.5450				
1000	-52.8916	-56.7265	-64.7332	-67.7065	-68.6545	-69.2671	-69.6106	-69.8340	-70.0100
	-70.1454	-70.2900	-70.4833	-70.7770	-71.1984	-71.8768	-72.9822	-74.5698	-76.9398
	-80.9922	-86.6949	-95.0689	-107.3278	-124.8773				
1500	-61.2843	-68.8552	-75.4519	-76.6612	-77.5812	-78.1766	-78.5468	-78.8120	-79.0401
	-79.2287	-79.4400	-79.7309	-80.1793	-80.8275	-81.8744	-83.5810	-86.0201	-89.6274
	-95.7784	-104.4861	-117.2841	-135.9407	-162.6998				
2000	-69.8111	-80.2632	-82.5766	-83.7709	-84.7878	-85.7141	-86.4696	-87.1088	-87.6895
	-88.1340	-88.5563	-89.0463	-89.7193	-90.6401	-92.0958	-94.4440	-97.7434	-102.4744
	-110.4485	-121.9501	-139.0212	-163.6259	-199.2556				

Southern Sound Propogation Loss for an Overcast, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtroc.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	91.68	0.99	2.5	0.5
2	254.0	267.00	91.68	1.00	2.5	0.5
1	0.0	267.00	91.68	0.97	1.0	0.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7789	-27.9674	-28.4524	-29.4299	-31.4692	-35.6492	-42.9369	-52.9516	-53.5199
	-50.0569	-46.4127	-43.1417	-40.2642	-37.9302	-35.8056	-33.8994	-32.3682	-31.0296
	-29.9185	-29.7462	-30.7510	-34.4151	-49.0023				

500	-50.4895	-53.2925	-60.1098	-67.7789	-66.7614	-65.9400	-65.4565	-65.2220	-65.1096
	-65.0789	-65.0889	-65.1337	-65.2207	-65.3543	-65.5761	-65.9524	-66.5313	-67.4600
	-69.0807	-71.3528	-74.8385	-80.1390	-87.9272				
Shadow Zone for Rhz =		1000							
	-56.2441	-60.6731	-71.6426	-82.8182	-89.8444	-97.5220	-103.5684	-107.6592	-105.6225
	-101.9173	-98.2337	-94.8429	-91.6130	-89.0390	-86.8161	-84.6995	-82.7256	-80.9691
	-79.0006	-77.5366	-77.1224	-78.3276	-81.2967				
Shadow Zone for Rhz =		1500							
	-62.4210	-70.2051	-83.9650	-89.6752	-97.0693	-105.0981	-111.4303	-113.5405	-112.8233
	-109.2811	-105.1872	-101.8766	-98.4822	-96.1154	-93.6353	-91.8825	-89.6921	-87.8741
	-86.0141	-84.1928	-83.6842	-85.1786	-88.1695				
Shadow Zone for Rhz =		2000							
	-68.0420	-78.9875	-88.8349	-94.9908	-102.2133	-110.1227	-117.1169	-118.6109	-117.6232
	-114.2659	-110.1855	-107.0758	-103.3401	-101.0673	-98.3407	-97.0724	-94.8018	-92.8797
	-90.9618	-88.9509	-88.4695	-90.0666	-93.1606				

Western Sound Propagation Loss for an Overcast, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtroc.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0   RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0   BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	91.68	0.99	2.5	0.5
2	254.0	267.00	91.68	1.00	2.5	0.5
1	0.0	267.00	91.68	0.97	1.0	0.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50.00	-27.7738	-27.9623	-28.4474	-29.4246	-31.4631	-35.6394	-42.9132	-52.9118	-53.5804
	-50.1017	-46.4342	-43.1504	-40.2665	-37.9294	-35.8031	-33.8960	-32.3645	-31.0257
	-29.9144	-29.7426	-30.7483	-34.4150	-49.0340				

500	-49.3007	-51.5690	-57.0381	-67.5512	-73.0675	-71.2659	-70.2444	-69.7622	-69.5161
	-69.4139	-69.3622	-69.3293	-69.3002	-69.2731	-69.2570	-69.2996	-69.4882	-69.9471
	-70.9383	-72.6029	-75.5408	-80.3226	-87.6968				
1000	-68.2009	-71.5741	-64.6995	-64.3591	-64.2392	-64.1875	-64.1944	-64.2342	-64.3056
	-64.3953	-64.5185	-64.7031	-64.9938	-65.4137	-66.0894	-67.1949	-68.8113	-71.2930
	-75.5683	-81.4727	-90.1241	-102.9226	-121.1445				
Shadow Zone for Rhz =		1500							
	-62.4315	-70.3035	-83.7785	-89.5798	-96.6320	-105.0321	-110.4759	-114.0919	-112.4598
	-109.1597	-105.3322	-101.7681	-98.7245	-96.3316	-93.9116	-91.8423	-89.5738	-87.9227
	-86.0553	-84.6562	-84.0120	-85.0954	-88.1853				
Shadow Zone for Rhz =		2000							
	-68.0161	-79.2301	-88.7035	-94.7221	-101.6380	109.8101	-116.6515	-119.4552	-117.5633
	-114.4119	-110.3048	-106.7360	-103.8199	-101.4330	-99.0810	-97.0198	-94.6635	-92.6788
	-91.1619	-89.6532	-88.8593	-89.9352	-93.0092				

Northern Sound Propagation Loss for an Overcast, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrow.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	276.00	100.00	0.97	5.1	2.3
2	92.0	276.00	100.00	0.97	5.1	2.3
1	0.0	277.00	84.99	0.95	5.0	2.6

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7500	-27.9258	-28.3832	-29.3095	-31.2476	-35.2289	-42.1927	-52.3082	-54.0650
	-50.5965	-46.7974	-43.4179	-40.4715	-38.0911	-35.9236	-33.9702	-32.3893	-30.9827
	-29.7261	-29.3390	-30.0613	-33.1479	-45.9130				

500	-45.9640	-47.2258	-50.7450	-57.8728	-63.6433	-64.9770	-65.8128	-66.3340	-66.6963
	-66.9056	-67.0414	-67.1245	-67.1605	-67.1552	-67.1174	-67.0553	-66.9801	-66.8742
	-66.8239	-67.1869	-68.3163	-70.5595	-75.1049				
1000	-54.4344	-58.5526	-66.9508	-70.5496	-71.6431	-72.3860	-72.8337	-73.1525	-73.4275
	-73.6424	-73.8440	-74.0530	-74.2907	-74.5653	-74.9553	-75.5478	-76.3460	-77.4353
	-79.2551	-82.0694	-86.5646	-93.5316	-105.2052				
1500	-63.9609	-72.5238	-78.9932	-79.9599	-81.0801	-82.2155	-83.2503	-84.2226	-85.1853
	-85.9341	-86.5703	-87.1352	-87.6708	-88.1998	-88.8816	-89.8702	-91.1305	-92.6191
	-94.8828	-98.7783	-105.5139	-115.5868	-133.1342				
2000	-72.8067	-80.2457	-80.5587	-81.4805	-82.7412	-84.3013	-85.9658	-87.8201	-90.0942
	-92.3648	-94.8762	-97.8152	-101.3634	-105.1587	-108.3678	-108.7271	-108.5850	-108.9645
	-109.1651	-112.2258	-120.7275	-133.6574	-157.0629				

Eastern Sound Propagation Loss for an Overcast, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrow.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	276.00	100.00	0.97	5.1	2.3
2	92.0	276.00	100.00	0.97	5.1	2.3
1	0.0	277.00	84.99	0.95	5.0	2.6

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
X(m)									
50	-27.7409	-27.9168	-28.3743	-29.3002	-31.2368	-35.2121	-42.1535	-52.2246	-54.1700
	-50.6840	-46.8402	-43.4366	-40.4781	-38.0920	-35.9213	-33.9662	-32.3846	-30.9775
	-29.7201	-29.3328	-30.0552	-33.1417	-45.9266				

500	-45.6151	-46.8631	-50.3194	-57.0016	-61.7058	-62.7981	-63.4631	-63.8764	-64.1682
	-64.3466	-64.4771	-64.5811	-64.6707	-64.7524	-64.8534	-64.9984	-65.1779	-65.3758
	-65.7090	-66.4572	-67.9542	-70.4875	-75.2923				
1000	-56.9157	-62.0294	-71.4063	-74.2852	-75.4504	-76.5726	-77.5368	-78.4067	-79.2339
	-79.8499	-80.3489	-80.7676	-81.1381	-81.4808	-81.9054	-82.5108	-83.2556	-84.0304
	-85.1089	-87.2808	-91.3907	-97.5140	-108.6477				
1500	-66.8787	-74.1045	-75.7916	-76.5959	-77.8178	-79.3356	-80.9593	-82.7780	-85.0346
	-87.3392	-89.9903	-93.3293	-98.0519	-105.6274	-113.0670	-103.4021	-101.1854	-101.5377
	-101.3206	-102.4265	-108.3110	-117.5552	-134.6921				
2000	-71.9152	-74.0812	-75.0293	-76.1567	-77.5043	-79.0660	-80.6707	-82.4117	-84.4882
	-86.4863	-88.5735	-90.7735	-92.9330	-94.5288	-95.3955	-95.7245	-96.5928	-99.2193
	-103.8103	-108.0683	-116.7136	-131.2339	-155.2357				

Southern Sound Propagation for an Overcast, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of geometry file
input\south.geo
Input name of frequency file
Input name of weather file
input\wtrow.wth
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	276.00	100.00	0.97	5.1	2.3
2	92.0	276.00	100.00	0.97	5.1	2.3
1	0.0	277.00	84.99	0.95	5.0	2.6

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8033	-27.9784	-28.4356	-29.3637	-31.3106	-35.3268	-42.4217	-52.7688	-53.4504
	-50.1106	-46.5608	-43.3199	-40.4433	-38.0963	-35.9469	-34.0026	-32.4253	-31.0213
	-29.7669	-29.3765	-30.0910	-33.1578	-45.6965				

Shadow Zone for Rhz =	500								
	-48.1174	-49.6036	-53.4711	-62.1932	-76.5674	-84.4671	-91.7226	-95.1661	-93.9632
	-90.8429	-86.8200	-83.2193	-79.8984	-77.5578	-75.1126	-72.8543	-70.9543	-69.2233
	-67.0449	-65.3941	-64.4793	-64.1962	-65.7906				
Shadow Zone for Rhz =	1000								
	-55.9785	-60.0758	-69.8178	-82.1927	-88.8515	-97.0785	-103.1723	-107.5454	-106.1831
	-102.6695	-98.7543	-95.2305	-92.0160	-89.6435	-87.3022	-85.0116	-82.9178	-81.0169
	-78.8831	-77.2118	-75.9398	-75.4890	-77.0433				
Shadow Zone for Rhz =	1500								
	-61.9450	-69.0156	-82.5244	-89.1664	-96.2814	-104.3921	-111.6040	-115.0544	-113.1876
	-109.9267	-105.9865	-102.2712	-99.0573	-96.7576	-94.3573	-92.0367	-89.9337	-88.0755
	-85.8447	-84.0614	-82.7326	-82.0786	-83.7410				
Shadow Zone for Rhz =	2000								
	-67.2644	-77.4637	-87.7150	-94.2768	-101.5381	-109.3596	-114.8460	-120.0258	-118.2882
	-114.5186	-110.8619	-107.3110	-104.0409	-101.8264	-99.4008	-97.0378	-94.9051	-93.0067
	-90.7928	-88.9460	-87.5829	-86.7933	-88.6659				

Western Sound Propagation Loss for an Overcast, Windy Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrow.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	276.00	100.00	0.97	5.1	2.3
2	92.0	276.00	100.00	0.97	5.1	2.3
1	0.0	277.00	84.99	0.95	5.0	2.6

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8127	-27.9876	-28.4449	-29.3734	-31.3221	-35.3448	-42.4643	-52.8564	-53.3469
	-50.0235	-46.5131	-43.2958	-40.4317	-38.0909	-35.9451	-34.0027	-32.4265	-31.0236
	-29.7711	-29.3825	-30.0999	-33.1746	-45.7352				

Shadow Zone for Rhz =	500							
-48.1449	-49.7524	-53.8853	-62.9212	-77.2573	-85.0437	-91.8607	-94.4002	-93.8187
-90.1372	-86.3122	-83.0116	-79.9063	-77.3579	-74.9945	-72.7073	-70.9659	-69.0189
-66.8383	-65.4455	-64.2283	-64.3000	-65.6949				
Shadow Zone for Rhz =	1000							
-56.0809	-60.4595	-70.7454	-82.4661	-89.3416	-97.2812	-103.6662	-106.9520	-105.7967
-102.3077	-98.5687	-94.7623	-91.7083	-89.3571	-87.0674	-84.9065	-82.8671	-80.7938
-78.8883	-76.9984	-75.7347	-75.5427	-76.9344				
Shadow Zone for Rhz =	1500							
-62.1500	-69.6829	-83.2665	-89.2166	-96.6181	-104.2955	-110.4865	-113.2150	-112.9570
-109.4323	-105.6842	-101.6828	-98.6877	-96.2897	-94.1931	-91.9690	-90.0107	-87.8308
-85.8929	-83.9468	-82.3990	-82.1769	-83.7110				
Shadow Zone for Rhz =	2000							
-67.6133	-78.3869	-88.1979	-94.4175	-102.0728	-109.7985	-115.3668	-119.6772	-117.9522
-114.0011	-110.7790	-106.5942	-103.5851	-101.2973	-99.2518	-97.0180	-95.0345	-92.7486
-90.9145	-88.8240	-87.1417	-87.0312	-88.6052				

Northern Sound Propagation Loss for a Clear, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcc.wth
Input name of geometry file
input\north.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 0.0
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	83.99	0.98	2.0	1.2
2	197.0	267.00	83.99	0.98	2.0	1.2
1	0.0	269.00	77.20	0.96	1.0	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0,100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7611	-27.9473	-28.4271	-29.3941	-31.4115	-35.5439	-42.7373	-52.7565	-53.7787
	-50.2584	-46.5245	-43.2027	-40.2991	-37.9527	-35.8225	-33.9162	-32.3905	-31.0623
	-29.9631	-29.8041	-30.8301	-34.4920	-49.0192				

500	-46.9260	-48.4486	-52.4650	-60.7634	-68.7423	-70.9709	-72.4501	-73.4215	-74.0880
	-74.3990	-74.4701	-74.3138	-73.9292	-73.3991	-72.7418	-72.0648	-71.5747	-71.3587
	-71.7202	-73.0938	-75.9624	-80.7550	-88.2320				
1000	-52.6334	-56.3503	-64.4283	-67.6368	-68.6147	-69.2564	-69.6169	-69.8518	-70.0377
	-70.1818	-70.3368	-70.5450	-70.8616	-71.3154	-72.0453	-73.2346	-74.9477	-77.5151
	-81.8916	-87.9845	-96.8562	-109.7015	-127.7411				
1500	-59.7241	-66.6980	-72.9844	-74.0612	-74.8798	-75.3860	-75.6903	-75.9088	-76.1063
	-76.2836	-76.4968	-76.8030	-77.2830	-77.9794	-79.1041	-80.9397	-83.5863	-87.5590
	-94.3370	-103.7632	-117.4618	-137.2928	-165.0978				
2000	-67.6406	-77.3959	-80.3345	-81.5926	-82.4383	-83.0309	-83.4302	-83.7379	-84.0226
	-84.2746	-84.5705	-84.9886	-85.6398	-86.5832	-88.1069	-90.5914	-94.1533	-99.4446
	-108.4430	-121.0415	-139.3837	-165.8211	-202.9988				

Eastern Sound Propagation Loss for a Clear, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcc.wth
Input name of geometry file
input\east.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 1.6
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	83.99	0.98	2.0	1.2
2	197.0	267.00	83.99	0.98	2.0	1.2
1	0.0	269.00	77.20	0.96	1.0	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.7542	-27.9405	-28.4203	-29.3871	-31.4033	-35.5309	-42.7062	-52.699	-53.8604
	-50.3202	-46.5538	-43.2146	-40.3023	-37.9519	-35.8194	-33.9119	-32.3859	-31.0573
	-29.9578	-29.7993	-30.8263	-34.4911	-49.0573				

500	-46.0145	-47.3564	-51.0574	-58.4195	-63.8271	-65.1463	-65.9603	-66.457	-66.7875
	-66.9667	-67.0801	-67.1609	-67.2327	-67.3134	-67.4433	-67.6783	-68.0496	-68.6356
	-69.7798	-71.7478	-75.0582	-80.1598	-87.8663				
1000	-54.5026	-58.7892	-67.2890	-70.5098	-71.5894	-72.3038	-72.7200	-72.9951	-73.2082
	-73.3653	-73.5269	-73.7394	-74.0622	-74.5276	-75.2799	-76.5049	-78.2431	-80.774
	-85.0476	-91.1096	-99.9876	-112.6947	-130.6791				
1500	-64.1787	-72.9881	-79.0215	-80.0365	-81.1549	-82.2607	-83.2348	-84.1115	-84.9391
	-85.5623	-86.1047	-86.6485	-87.2943	-88.1019	-89.3268	-91.2671	-93.9351	-97.5909
	-103.5933	-112.4518	-125.8027	-144.5542	-171.6306				
2000	-73.2216	-80.4853	-80.7752	-81.7245	-83.0006	-84.5567	-86.1869	-87.9677	-90.1150
	-92.2473	-94.6266	-97.4622	-100.9406	-104.6861	-108.2613	-110.4706	-112.6922	-115.8989
	-121.0504	-130.8734	-148.3159	-172.6601	-208.8132				

Southern Sound Propagation Loss for a Clear, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcc.wth
Input name of geometry file
input\south.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0   RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0   BEARING OF AIRCRAFT = 3.1
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	83.99	0.98	2.0	1.2
2	197.0	267.00	83.99	0.98	2.0	1.2
1	0.0	269.00	77.20	0.96	1.0	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8008	-27.9865	-28.4663	-29.4350	-31.4596	-35.6204	-42.9207	-53.0824	-53.3157
	-49.9052	-46.3492	-43.1263	-40.2731	-37.9510	-35.8343	-33.9348	-32.4123	-31.0868
	-29.9906	-29.8314	-30.8561	-34.5142	-48.8783				

500	-55.3386	-57.4272	-57.6027	-55.9200	-55.5940	-55.5710	-55.5661	-55.5811	-55.6152
	-55.6604	-55.7251	-55.8239	-55.9815	-56.2103	-56.5790	-57.1823	-58.0629	-59.4114
	-61.7247	-64.9003	-69.5117	-76.2454	-85.6594				
Shadow Zone for Rhz =		1000							
	-56.1685	-60.3408	-70.7496	-82.4164	-89.5818	-97.4822	-103.5317	-106.4921	-105.8002
	-102.0886	-98.1899	-94.7253	-91.5550	-89.0869	-86.9728	-84.5859	-82.9126	-80.8191
	-78.9554	-77.6634	-77.6786	-78.8264	-81.9098				
Shadow Zone for Rhz =		1500							
	-62.2704	-69.7257	-83.5785	89.2972	-96.8683	-104.8676	-112.2088	-114.1947	-112.6371
	-109.0729	-105.2638	-101.8647	-98.6306	-96.0571	-94.0207	-91.6413	-89.8981	-87.7543
	-85.7322	-84.4246	-84.5708	-85.7897	-89.0178				
Shadow Zone for Rhz =		2000							
	-67.7090	-78.3920	-88.6733	-94.5055	-102.0235	-110.2910	-117.0053	-119.8579	-117.8118
	-113.8874	-110.0984	-107.0275	-103.5560	-101.0725	-99.1193	-96.6279	-94.9797	-92.6711
	-90.6244	-89.2316	-89.4622	-90.7313	-94.0160				

Western Sound Propagation Loss for a Clear, Calm Winter Day - Frequencies 25 - 4000Hz

Input name of weather file
input\wtrcc.wth
Input name of geometry file
input\west.geo
Input name of frequency file
input\mout.fr
Input name of ground file
input\forgras.grd
Input name of variational file
input\distance.var

SINGLE FREQUENCIES

SOURCE HEIGHT(Zs) = 2.0 RCVR HEIGHT(Zr) = 1.0
CLOSEST APPROACH(L) = 0.0 BEARING OF AIRCRAFT = 4.7
RECEIVER RIGHT OF FLIGHT PATH

INTERF	HEIGHT	TEMP	REL_HUM	PRES	WIND_SP	WIND_DIR
3	438.0	267.00	83.99	0.98	2.0	1.2
2	197.0	267.00	83.99	0.98	2.0	1.2
1	0.0	269.00	77.20	0.96	1.0	3.5

GROUND	SIGMA	POROSITY	DEPTH
1	48.00	0.82	0.100
2	330.00	0.68	

FREQUENCIES (Hz)

X(m)									
	25.0	31.5	40.0	50.0	63.0	80.0	100.0	125.0	160.0
	200.0	250.0	315.0	400.0	500.0	630.0	800.0	1000.0	1250.0
	1600.0	2000.0	2500.0	3150.0	4000.0				
50	-27.8078	-27.9934	-28.4731	-29.4419	-31.4676	-35.6330	-42.9507	-53.1257	-53.2336
	-49.8507	-46.3265	-43.1205	-40.2757	-37.9577	-35.8429	-33.9443	-32.4218	-31.0960
	-29.9986	-29.8366	-30.8561	-34.4995	-48.7712				

Shadow Zone for Rhz = 500

-48.1444	-497473	-53.9843	-62.7133	-77.1481	-84.8439	-92.0409	-94.8828	-93.6406
-89.9430	-86.2898	-82.6570	-79.7166	-77.1111	-74.9822	-72.7073	-70.7186	-68.9657
-67.3581	-66.2968	-66.2131	-67.3421	-70.2527				

Shadow Zone for Rhz.= 1000

-56.1224	60.5038	-70.8117	-82.5405	-89.2753	-97.3031	-103.9311	-107.5907	-105.6543
-102.2926	-98.3228	-94.8025	-91.7865	-89.1283	-87.0396	-84.7677	-82.5788	-80.9274
-79.0316	-77.6468	-77.3217	-78.8569	-82.0285				

Shadow Zone for Rhz = 1500

-62.1775	-69.7470	-83.5479	-89.5297	-96.5784	-104.3981	-110.8844	-114.6708	-112.6440
-109.0585	-105.5147	-101.7315	-98.8665	-96.2659	-94.0486	-91.8748	-89.5024	-88.0987
-86.0984	-84.4988	-84.0364	-85.6697	-89.1976				

Shadow Zone for Rhz = 2000

-67.6670	-78.6645	-88.7313	-94.8041	-101.2837	-109.7442	-115.4172	-118.9101	-117.4828
-114.3185	-110.5014	-106.6729	-103.8847	-101.2527	-99.1574	-96.9421	-94.3940	-93.1418
-91.1547	-89.3782	-88.8146	-90.6624	-94.2587				